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Cotton Ginners Handbook

Cotton Ginners Handbook

W.S. Anthony and William D. Mayfield,
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ABSTRACT

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The principal function of the cotton gin is to separate lint from seed, but the gin must also be equipped to remove foreign matter, moisture, and other contaminants that significantly reduce the value of the ginned lint. Gins must produce a quality of lint that brings the grower maximum value while meeting the demands of the spinner and consumer. Operating gin machinery in accordance with the recommended speeds, adjustments, maintenance, and throughput rates will produce the highest possible fiber quality. A standardized sequence that includes dryers to obtain the proper moisture level as well as machines to remove the foreign matter is recommended for processing cotton at the gin. This publication addresses the key ginning issues concerned with facilities, machinery, cleaning, ginning, drying, packaging, and waste collection and disposal as well as ancillary issues concerned with pollution, management, economics, energy, insurance, safety, cotton classification, and textile machinery.

Keywords: Ginning, machinery, cleaning, packaging, pollution, textile, management, economics, moisture, heating, cotton, drying, safety, insurance, cotton classification, saw ginning, and roller ginning.

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SECTION 1— DEVELOPMENT OF THE COTTON GIN

William D. Mayfield and W.S. Anthony

Cotton was used for textile products several centuries before recorded history (Lewis and Richmond 1968). Columbus and his European successors found cotton being grown for spinning and weaving into textiles in the West Indies, Mexico, and Peru (Brooks 1911). This cotton fiber was pulled off the seed either by hand or by using a Churka gin (fig. 1–1), a small hand-powered machine with two hardwood pinch rollers that gripped the fiber and pulled it away from the seed.

The English who settled at Jamestown in the early 1600's brought cotton-seed to determine if the crop would grow in the colony. England had the technology to weave cotton-wool blends but needed a supply of cotton. The colonists grew cotton for export to England but were forbidden from manufacturing cotton goods. However, having brought knowledge of spinning and weaving, they grew small garden plots of cotton and produced some of their clothing, bedding, and home furnishings.

Textile imports from England were suddenly stopped during the Revolutionary War, and cotton acreage expanded rapidly to meet the domestic needs. Large quantities of homespun textiles were produced, and some small factories were built. When the war was over, the United States desired to be self sufficient and the large English demand created a strong market for raw cotton.

Before southern planters could sell cotton, the lint had to be separated from the seed. The upland cottons that grew best in the South would not gin satisfactorily on the Churka gin because the fiber was attached to the seed too strongly. Consequently, the fiber was picked from the seed by hand; this process, however, was so slow that it would take a person a day to gin 1 lb of lint (Brooks 1911).

On March 14, 1794, Eli Whitney received a patent on a machine to gin cotton. Whitney's invention was rapidly put to use throughout the South. Within a year, gins were being manufactured and operated in key production areas. His gin used either saws or metal spikes driven into a wooden cylinder in concentric rows. The spikes or saws passed through narrow slots to remove cotton fiber from the seed one batch at a time. To operate the gin, the ginner placed a few handfuls of seed cotton in the machine and then turned the cylinder by hand; the gin then removed the fibers from the seed and brushed them into a pile behind the machine. The gin was then stopped, the seeds were removed, and the process was repeated.

Henry Ogden Holmes, a plantation blacksmith from South Carolina, received a patent on May 12, 1796, for an improved gin. The Holmes gin (fig. 1–2) used metal saws positioned on a shaft to replace Whitney's concentric rows of spikes or saws. More importantly, the slots or "ribs" in the Holmes gin allowed the cleaned seeds to fall out the bottom, making ginning a continuous-flow process rather than a batch process. Whitney soon recognized the value of Holmes' improvements and used them in his machine (Bennett 1961). Modern saw gins use Holmes' basic principles along with many improvements.

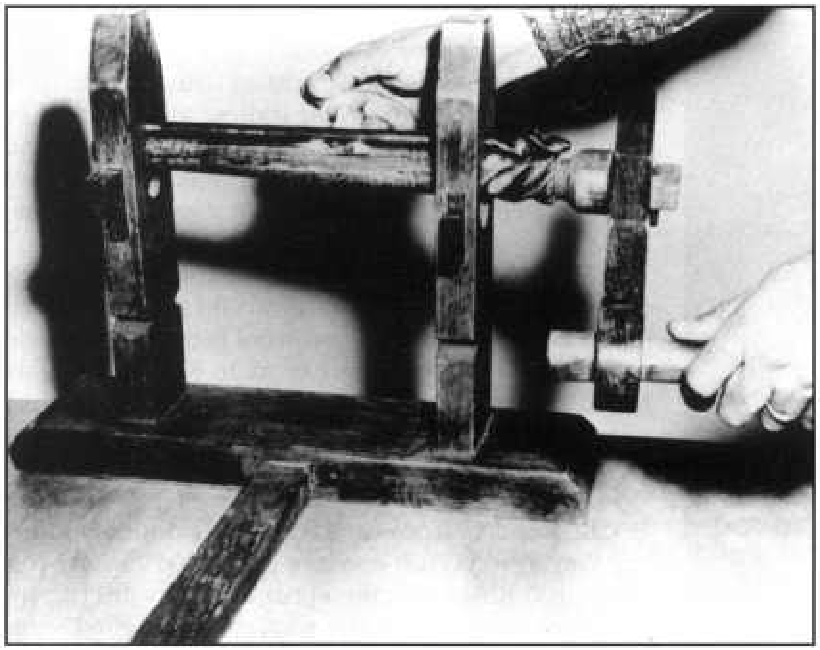

Figure 1–1. Churka gin (circa 1940)—used to pinch fibers from the seed

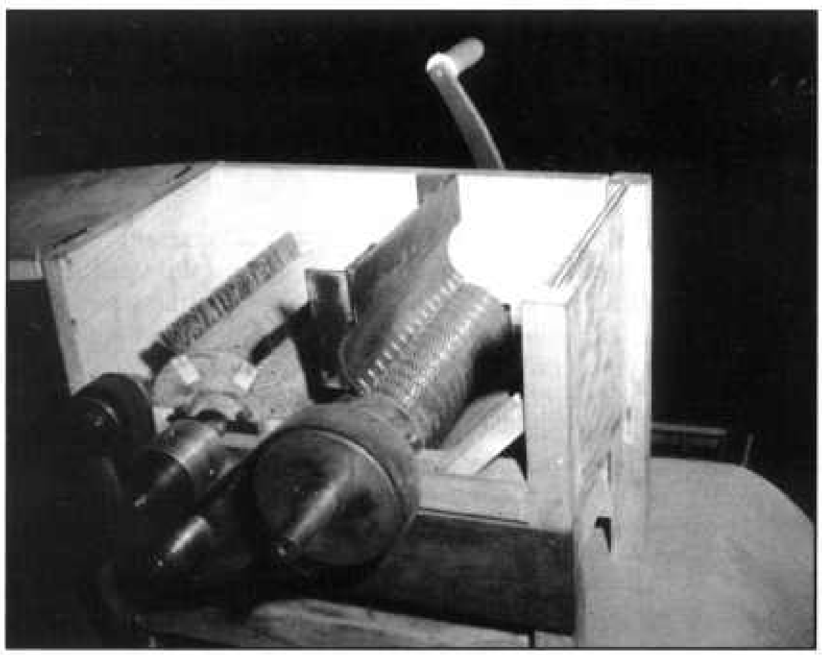

Figure 1–2. Metal saw gin stand patented by H. Ogden Holmes as an improved version of the gin developed by Eli Whitney

The development of the saw-type cotton gin resulted in an immediate, dramatic increase in cotton production in the United States. In the 40 yr following the invention, production more than doubled during each succeeding decade. By the outbreak of the Civil War, the Cotton Belt States were producing about 4 million bales annually—more than half the world supply of cotton (Brown 1927). As production increased, the gin became a symbol of the prosperous plantation owner.

Expanding acreage, however, brought with it a new problem. Workers could not pick the cotton from the stalk as carefully as before and picked more trash with the cotton. The trash made the fiber less desirable to mills because it increased waste and the fiber did not spin as well. For a while, the trash was picked from the cotton by hand. But this was a weary task to perform at night for the laborers who had worked in the fields all day and for their family members, so attempts were made to mechanically clean the cotton.

Packaging the lint was a major problem at early gins. The usual practice was to package it in sacks hung from frames built around holes in the floor. The cotton was stuffed through the holes into the sacks and packed down by workers' feet. Screw presses for packaging cotton were introduced in about 1800 and were used extensively for almost 100 yr.

Holmes' continuous-flow gin created an obvious need for continuous-flow mechanical feeders. The first successful gin feeder was developed by Alex Jones in 1834. In 1884, systems to handle bulk seed cotton came on the market and made it possible to feed several gin stands simultaneously. The first system conveyed seed cotton by pneumatic suction from wagons to a screen box that acted as a separator and fed a distributor. The conveying system and the mechanical feeder took much of the hand labor from ginning, and gins were soon powered primarily by mules or water wheels (Bennett 1962).

In the 1800's and early 1900's, refinements in the gin stand and in equipment for cleaning, conveying, and packaging met the needs of plantation owners and allowed production to expand. Cotton could be harvested in clear weather and ginned in rainy weather. As the cost of gins continued to increase because of the additional cleaning equipment needed for trashier cotton, commercial installations began to replace plantation gins. Although the machinery became more efficient in removing trash and moisture, the harvesting methods became rougher; more cotton was graded lower, costing producers millions of dollars each year. The damp, trashy cotton would not spin well or make high-grade yarn and was sold at a lower price.

Because of these problems, the U.S. Department of Agriculture established a cotton ginning research program in 1931. Engineers soon developed a seed cotton dryer that was rapidly put into use throughout the Cotton Belt (Moore 1977).

Following World War II, machines rapidly replaced hand harvesting. Mechanically harvested seed cotton contained even more foreign matter. Seed cotton cleaners (including inclined cleaners, impact cleaners, stick machines, and bur machines) and lint cleaners were developed to remove as much of this foreign material as practical. Because cotton cleans much easier when it is dry, gins quickly installed additional drying equipment in the late 1950's. Now most gins use two stages of seed cotton drying, three or four seed cotton cleaners, and two lint cleaners to clean and dry cotton.

Mechanical harvesting compressed the ginning season and put pressure on gins to increase their processing capacity. Manufacturers greatly increased the capacity of individual gin stands in the 1950's, and other components were assembled to produce high-volume ginning systems.

High-volume gins made it feasible to include a press that compresses cotton bales to their final density at the gin. The presses allowed major improvements to be made, such as standardization of bale dimensions, coverings, and strapping materials. More than 90 percent of the U.S. crop is currently pressed into universal density (UD) bales at the gin (Supak et al. 1992).

The modular system of handling seed cotton has been used since 1972 and was used on 63 percent of the 1991 crop; since then its usage continues to increase. This system includes transportation from the field to the gin, but its major economic advantage comes from temporary seed cotton storage, which improves harvester utilization, allows gins to operate more hours per year, and therefore reduces ginning costs.

The major cotton ginning developments are summarized in table 1–1. Since the invention of the saw cotton gin, the size, capacity, and annual volumes of individual gins have steadily increased. Recent production and ginning trends are summarized in table 1–2.

Typical modern cotton gins are capable of drying, cleaning, ginning, and baling 30–60 bales/hr, but some gins can produce over 100 bales/hr. Modern gins also include the equipment to handle and temporarily store seed cotton and to collect and dispose of waste materials. Many of these gins have facilities for long-term storage of baled lint and whole cottonseed.

The modern cotton gin is a large agricultural business. In addition to processing seed cotton into fiber and seed, many gins provide a variety of other services, such as marketing assistance and selling crop production supplies, to their cotton producers.

Table 1–1.
Major cotton ginning developments

Period	Development	Inventor(s)
B.C.	Churka gin	Unknown
1794	Gin invented	Eli Whitney
1796	Continuous-flow gin	Henry Ogden Holmes
1800–1820	Screw presses (several developments)	
1834	Mechanical feeder	Alex Jones
1884–1900	Bulk seed cotton handling (several developments)	
1900–1950	Seed cotton cleaners (several developments)	
1931	Seed cotton dryer	Charles A. Bennett
1947–1951	Lint cleaners	Eugene Brooks, Victor Stedronsky, and Charles Shaw
1972	Modular seed cotton handling	Lambert Wilkes and J.K. Jones

Table 1–2.
U.S. cotton ginning statistics

Year	Gins (number)	Production (1,000 bales)	Average volume (bales/gin)
1900	29,214	9,345	320
1920	18,440	13,271	720
1940	11,650	12,298	1,056
1960	5,395	14,265	2,644
1970	3,750	10,112	2,697
1980	2,254	10,826	4,803
1990	1,533	15,065	9,826

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SECTION 2—COTTON PRODUCTION, HARVESTING, AND STORAGE

Production Practices

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The sequence of production practices begins in the fall after the previous crop is harvested. The first operations usually include shredding stalks, ripping out roots, and then disking. Depending on the soil type, chiseling or moldboarding to a depth of 12–15 inches may be done in alternate years. In the Midsouth and Southeast, chiseling is done annually. In irrigation regions, land leveling may be performed every 2 or 3 yr for proper flow of irrigation water. Fertilizer and herbicides generally are applied and incorporated into the soil before the land is listed (bedded) in preparation for needed irrigation or planting. In nonirrigated areas, the prepared beds are allowed to store winter rains and firm up before planting. These beds may need to be reshaped with a sweep cultivator or disk bedder to control winter weeds. Preplant herbicides may be incorporated with a rolling cultivator prior to planting.

Fertilization

Soil characteristics and past fertilization and cropping practices can cause a wide range of fertility levels in cotton soils. Therefore, fertility programs should be based on soil test analyses. In some stripper areas of Texas and Oklahoma where moisture is limited, 20–40 lb of nitrogen/acre must be added to produce one bale/acre. In the irrigated West, 150–250 lb of nitrogen/acre are required to achieve yields of two to four bales/acre. Generally, a portion of the nitrogen can be side-dressed before the last cultivation or applied to the foliage throughout the season. As yield levels increase, higher rates and deep placement of phosphate and potassium have become necessary in some regions to maintain consistently high yields. Minor elements may be applied to the soil before planting or to the foliage. Recent advances in irrigation systems and technology permit the application of plant nutrients through irrigation water.

Weed Control

Profitable cotton production requires a sound weed control program. Control of weeds is essential to obtain high lint yield and quality. Cotton yields and harvesting efficiency can be reduced by as much as 30 percent by weeds.

Herbicides have been widely used for weed control since the early 1960's. The popularity of herbicides can be attributed to their effectiveness in controlling a wide range of weed species. Improvement in herbicide efficiency has permitted cost-effective weed control throughout the growing season. Application methods include preplant treatment to foliage of existing weeds, preplant soil incorporation, preemergence, directed postemergence, and over-the-top postemergence. Soil covering the seed zone should be sufficiently elevated and have no depressions. In the depressed areas, preemergence herbicides in runoff water can become concentrated and result in stand loss.

Cultivar Selection

Yield, fiber quality (length, strength, fineness, and maturity), and disease resistance are the primary factors used to select cultivars. Continuous progress has been made in the last 25–30 yr in the development of earlier maturing cultivars. Cotton breeders have shortened the period from planting to harvesting by as many as 30 days. This increased earliness has shortened the fruiting period and therefore the window for insect control. Earlier harvest has improved lint grades primarily because the fiber is less weathered. When the producer is forced to plant late, earliness may be the primary consideration in cultivar selection.

Cotton breeders have made significant progress in developing disease-resistant cultivars. Control of bacterial blight and wilt diseases has been accomplished primarily through the development of tolerant cultivars. Diseases such as Verticillium wilt and the Fusarium wilt-nematode complex may be the major considerations in determining the best cultivar to grow in a specific field or on a specific farm. In areas or fields with severe disease incidence, the first consideration given to selecting cultivars should be high levels of resistance to the diseases present.

Several production and harvesting practices influence the producer's decision in cultivar selection. Producers with irrigation, which is usually associated with high yield potential, will likely select cultivars that are different from those selected by producers without irrigation. Stormproof cultivars are normally harvested in a single operation with a stripper harvester. In most cases, producers that harvest with a spindle-type picker will select picker-type cultivars. Generally the less storm resistant boll-type cultivars are better adapted for spindle harvesters.

Stand Establishment

A key step in the production of any cotton crop is obtaining a uniform stand of vigorous seedlings. Several factors that play an important role in achieving such a stand include seedbed preparation, soil moisture, soil temperature, seed quality, seedling disease infestation, fungicides, and soil salinity. Planting high-quality seed in a well-prepared seedbed is a key factor in achieving early, uniform stands of vigorous seedlings. High-quality planting seed should have a germination rate of 50 percent or higher in a cool test. In a cool/warm test, the seed vigor index should be 140 or higher.

Seeding rates of 4–6 seed/foot of row are recommended to obtain a plant population of 35,000–50,000 plants/acre. A suitable planter metering system should be used to ensure uniform spacing of seed regardless of seed size. Seed germination and seedling emergence rates are closely associated with a temperature range of approximately 60–100 °F, and there is a straight-line relationship between crop development and average daily temperature accumulation (measured in degree days). If a base temperature of 60 °F is chosen, the degree days (DD60) or heat unit accumulation is obtained by subtracting the base temperature from the average daily temperature. Good seedling emergence can be expected when there is a minimum of 15 DD60 accumulated during the 5 days following planting.

Incidence of early season seedling diseases can hamper uniform stands and result in the need to replant. Important seedling disease pathogens such as *Pythium*, *Rhizoctonia*, *Fusarium*, and *Thielaviopsis* can reduce plant stands and cause long skips between seedlings. Only seed that have been properly treated with one or more fungicides should be planted. Producers should use an in-furrow fungicide in fields that have a history of serious seedling disease losses in 3 out of 5 yr. Once seedling losses have occurred, the grower should determine whether the number of remaining healthy seedlings is sufficient to produce a profitable crop. If seedling loss is severe enough to require replanting, the grower should consider selecting cultivars that are not only high producers of high-quality fiber but are also better suited for late planting.

Soil salinity can affect stand establishment, especially in the western production region. High soil salinity can interfere with efforts to obtain vigorous, uniform plant stands. Saline conditions, however, can be improved in several ways such as preplant irrigating to leach out salts, changing irrigation techniques, and using higher quality irrigation water.

Water Management

Under irrigated production, it is important to maintain sufficient soil moisture to ensure that bolls intended for harvest will reach full maturity. As the crop nears maturity, the producers should manage irrigation to slowly decrease the soil moisture content and thereby encourage plant cut-out prior to harvest. This procedure will generally improve fiber quality because a well-fruited plant that is beginning to cut out responds to defoliation better than a rapidly growing plant. A well-managed defoliation program reduces leaf trash that can adversely affect the grade of the harvested cotton. Growth regulators such as PIX are useful defoliators because they control vegetative growth and contribute to earlier fruiting.

Cotton is similar to other crops with respect to water use during different plant developmental stages. Water use is generally less than 0.1 inch/day from emergence to the first square. During this period, loss of soil moisture by evaporation may exceed the amount of water transpired by the plant. Water use increases sharply as the first blooms appear and reaches a maximum level of 0.25–0.4 inches/day during the peak-bloom stage. Water requirement refers to the total amount of water (rainfall plus irrigation) needed to produce a crop of cotton. This requirement varies by production region. The annual water requirement for cotton is 27–50 inches in Arizona, 30–40 inches in the San Joaquin Valley of California, 20–24 inches in the High Plains of Texas and Oklahoma, and 26–30 inches in the Midsouth and Southeast.

Insect Pest Management

Insect populations can have an important impact on cotton quality and yield. Early season population management is important in promoting balanced development of the crop's fruit and vegetative growth. Protecting early fruit positions is essential to achieving a profitable crop. Over 80 percent of the yield is set in the first 3–4 weeks of fruiting. Once the square can support weevil reproduction (when the square is one-third grown), producers should consider boll weevil control with insecticide applications. Sequential applications may be needed to ensure that early fruit set is maintained. Some regions have adopted the delayed uniform planting program as a boll weevil control strategy. During the fruiting period, producers should scout their cotton at least twice a week to monitor insect activity and damage. In some production regions such as the irrigated west and the Rio Grande Valley, insects such as the white fly can reduce fiber quality by producing honey dew that causes sticky lint. Control of thrips, fleahoppers, tarnished plant bugs, and lygus bugs is essential in maintaining earliness in cotton production.

Stalks should be destroyed after the crop is harvested. Early stalk destruction has become an important method for controlling boll weevils and pink bollworms in many areas of the Cotton Belt. Stalk shredding and plow-up can help prevent late-developing immature fruit from becoming a food source for diapausing weevils and pink bollworms.

Cotton producers must incorporate several management techniques into their cotton production system to control insects effectively. In addition to prompt stalk destruction, they should strive for early harvest. Good seedbed preparation in the fall is beneficial for early planting operations. Early planting gives the crop an early start and helps to ensure an early harvest by reducing mid- and late-season insect damage. Later in the season the producer must properly time insecticide treatments to reduce diapausing boll weevil and pink bollworm populations. Application of insecticides with defoliants is an economical method for reducing late-season insects. A sound insect control program maximizes the use of natural control agents and cultural practices. Field observations should be made frequently to determine the extent of plant damage from harmful insects. When control measures are needed, the producer should use insecticides judiciously so that beneficial insect populations are maintained. Migration of the beneficial species from other crop or noncrop areas to cotton fields is important to achieve a successful pest control program.

Harvest Preparation

A profitable cotton crop includes two basic components: high yield and high-quality lint. Good season-long cultural practices are associated with high yields, and timely cultural practices also complement harvest preparation. A well-fruited, uniform crop begins with an early, uniform stand of vigorous plants and with early season insect control. Sound weed control practices that result in weed-free cotton further enhance harvest preparation. A desirable bed profile after planting is important in stand establishment as well as in subsequent field operations. A ridge of sufficient width (spanning 6–8 inches on each side of the seed drill) should be maintained to facilitate postemergence field operations. Maintaining a uniform, wide ridge for cotton pickers or stripper cotton headers to operate improves harvesting efficiency and contributes to higher quality seed cotton.

Effective crop termination includes good water and fertility management in irrigated regions. This involves maintaining sufficient soil nutrients and moisture to ensure full maturity of bolls intended for harvest while slowly decreasing soil moisture and nutrients to encourage plant senescence. In nonirrigated cotton, the ideal time for harvest preparation is when some natural leaf drop has occurred and little or no regrowth is occurring. Hot, sunny weather and high relative humidity promote the desired defoliation response to harvest-aid chemicals.

To ensure high-quality lint, the grower should treat only mature cotton with harvest-aid chemicals. Several methods may be used to determine when to apply the harvest-aid treatment. Some of these methods are based on heat unit accumulation or the percentage of open bolls. Other methods involve using cotton growth simulation models. To minimize regrowth and reduce the time open bolls are exposed to weathering, the applicator should be sure that the acreage treated in a specific time period does not exceed harvesting capacity.

In selecting harvest-aid chemicals, the grower must consider plant, soil, and weather conditions. Suboptimum weather may require certain tank-mix combinations to enhance defoliation. Defoliation followed by desiccation treatment improves the grade of stripper-harvested cotton, especially when hairy cultivars are grown. Boll-opening chemicals, such as Prep, may be used to improve lint quality by promoting earlier or simultaneous opening and hence earlier harvesting of cotton that is late maturing or that has not opened uniformly.

Harvesting

J.R. Williford, A.D. Brashears, and G.L. Barker

General Guidelines

Two types of mechanical harvesting equipment are used to harvest the U.S. cotton crop—the spindle picker and the cotton stripper. The spindle picker is a selective-type harvester that uses tapered barbed spindles to remove seed cotton from only well-opened bolls. This harvester can be used more than once to provide stratified harvests. The cotton stripper is a nonselective or once-over harvester that removes not only the well-opened bolls but also the cracked and unopened bolls along with the burs and other foreign matter. The stripper harvester is commonly used in the High Plains and Rolling Plains area of Texas, the dryland area of the Texas Rio Grande, and Oklahoma.

Agronomic practices that produce a high-quality uniform crop will generally contribute to good harvesting efficiency. The field should be well drained and rows laid out for effective use of machinery. Row ends should be free of weeds and grass and should have a field border of 25–30 ft for turning and aligning the harvesters with the rows. The border also should be free of weeds and grass. Disking creates adverse conditions in rainy weather, so chemical weed control or mowing should be used instead. Uniform stands of 40,000–60,000 plants/acre encourage plant growth suited for mechanical harvest. Plant height should not exceed about 48 inches for cotton that is to be picked and about 36 inches for cotton that is to be stripped. Plant height can be controlled to some extent by using chemical growth regulators at the proper growth stage. Production practices that set the bottom boll at least 4 inches above the ground should be used. Cultural practices such as fertilization, cultivation, and irrigation during the growing season should be carefully managed to produce a uniform crop of well-developed cotton.

Chemical defoliation is a cultural practice that induces abscission (shedding) of foliage (Barker et al. 1976). In most areas where the picker harvester is used, defoliants are applied to help minimize green-leaf-trash contamination and promote faster drying of early morning dew on the lint. Defoliants should not be applied until at least 60 percent of the bolls are open. After a defoliant is applied, the crop should not be harvested for at least 7–14 days (the period will vary depending on chemicals used and weather conditions).

Chemical desiccants may also be used to prepare plants for harvest. Desiccation is the rapid loss of water from the plant tissue and subsequent death of the tissue. The dead foliage remains attached to the plant. For harvesting with pickers, only the leaf blade needs to be desiccated, so harvesting can usually be initiated 2–3 days after a desiccant is applied.

The advantage of applying a defoliant or a desiccant must be weighed against the disadvantages caused by the loss of foliage. In general, the cotton grade is improved about one-half grade, but yield may be slightly reduced. Defoliation will also increase the risk of preharvest loss due to rainfall and adverse weather, since the leaves are removed and the cotton is more exposed. Depending on weather conditions, regrowth of leaves may occur following defoliation. The new leaves are extremely hard to remove with additional applications of defoliants.

The current trend in cotton production is toward a shorter season and one-time harvest. Chemicals that accelerate the boll opening process are becoming available and being applied with the defoliant or soon after the leaves drop. These chemicals allow earlier harvests and increase the percentage of bolls that are ready to be harvested during the first harvest. Because these chemicals have the ability to open or partially open immature bolls, the quality of the crop may be severely impacted (e.g., the micronaire may be low) if the chemicals are applied too early. Bolls should be at least 35–40 days old before these chemicals are applied. The current Extension Service recommendations for use of defoliants, desiccants, and boll openers should be consulted.

Today's harvesters are often used in conjunction with seed cotton storage equipment such as modules. The type of storage or seed cotton processing may place additional constraints on the harvest process. For example, if the seed cotton is to be placed in a module for storage, the cotton should not be harvested until it has dried to a moisture content of 12 percent or less on the plant and the harvested seed cotton should be free of green material, such as leaves and grass.

When heavy dew occurs, it may be advantageous to carry the first basket harvested each day directly to the gin for immediate processing. The amount of green matter in the seed cotton should be low, since it is generally higher in moisture content and will raise the moisture content of the seed cotton when mixed with it. Potential sites for modules should be selected prior to harvest. These sites should be on firm, well-drained land and should be easily accessible by the module builder, the harvester, and the module mover.

Guidelines for Spindle Pickers

Mechanical pickers are complex machines that require proper maintenance and adjustments to operate at high efficiency. Spindle pickers can harvest at 95-percent efficiency but are commonly operated at only 85- to 90-percent efficiency. The manufacturers manuals should be closely followed to ensure that the harvesters perform at maximum efficiency and cause minimum damage to cotton fiber and seed. Any worn or misaligned parts should be replaced before the season starts. Special care should be given to the spindles, moistener pads, doffers, bearings, bushings, and cam track.

Some key adjustments need to be made at the beginning of the season and checked on a weekly basis. The stalk-lifter fingers should be adjusted so that they lift the low bolls up into the picking zone. Drum tilt should be adjusted so that the rear of the drum is about 1 inch higher than the front. The pressure on the compressor shield should be adjusted based on the crop conditions. If the crop has many green bolls (typical at first harvest), the pressure should be light to medium to allow enough clearance for the green bolls to pass between the spindles and plate. As the season progresses, the pressure can be increased and clearance reduced to increase the aggressiveness of the spindles in removing the cotton from the plant.

Daily and/or hourly adjustments may be required for spindle moisture and spindle-to-doffer clearance. The picker bars should be inspected to ensure that there are no broken, damaged, or dead spindles. Each bar should be shimmied to the same height. One major problem often encountered with spindle harvesters is spindle twists. This problem is often caused by improper adjustment of the spindle to the moistening pads and doffers. Improper adjustment is indicated by poor picking efficiency, dirty spindles, green stain or gumlike plant residue on the spindles, or lint wrapped around spindles. Grass and green leaves also contribute to spindle twists. The operator should make sure that the spindle-doffer clearance and spindle-moistening pad adjustment are correct (consult operators manual) and should add just enough water or moistening agent to keep the spindles clean. The spindles should ripple the moistening pad slightly, and each doffer lug should run as close as possible to the spindle without touching it. If the doffer pad touches the spindle, the lint may become contaminated with minute doffer particles. Polyurethane doffers are preferred to rubber ones to prevent contamination of the lint.

Moisture is added to the spindles to keep them clean and to enhance the adherence of the fiber to the spindle. Harvesting should begin after the dew has dried and after the relative humidity is below 60 percent. The spindles generally require less moisture in the morning than in the afternoon. Tap water is usually sufficient to keep the spindles clean. Wetting agents, spindle cleaners, or a soluble oil may also be added to the water. These additives are usually helpful when harvesting rank cotton that has green leaves.

With spindle harvesters, cleanliness is very important. The manufacturer's lubricating guide should be followed, and excess oil and grease washed from the picker heads before going to the field. After each basket of cotton is dumped, the picking units and conveying system should be checked for trash and other contaminants. Lint streamers should be removed from the basket and cleaning grates.

A typical bale of spindle-harvested cotton contains 75–150 lb of plant parts/ 1,500 lb of seed cotton.

Guidelines for Cotton Strippers

The cotton stripper is a simple and efficient machine for harvesting cotton and has the capacity to harvest up to 99 percent of the cotton from the plant. Cotton strippers use either finger-type or roll-type harvesting mechanisms. The finger-type mechanism utilizes multiple fingers made from metal angles with the vee turned up and operating at a 15- to 20-degree approach angle with the ground. This method of harvest is well adapted to dryland cotton produced in narrow rows (20 inches or less) having plants that are 24 inches or less in height.

The roll-type strippers use two 7-inch-diameter stripper rolls angled 30 degrees with the ground and rotating in opposite directions with the upward direction next to the plant (Brashears 1988). Each roll consists of three brushes and three paddles mounted in alternating sequence. The roll-type harvester is capable of harvesting cotton produced under dryland or irrigated conditions. Under dryland conditions plants are likely to be small, and production may be as low as 0.5 bale/acre. Under irrigated conditions plants are generally large and branchy, and yields may be up to two bales per acre. Row spacing for the roll-type harvester is normally between 30 and 40 inches.

Both types of stripper harvesters use screw-type augers and pneumatic handling systems to convey cotton to a high-capacity basket. A pneumatic system to separate green bolls and heavy trash is incorporated into the air handling system. The initial cost and operating cost are less for the stripper than they are for the cotton picker. Unfortunately, the stripper harvests large amounts of foreign material. A typical bale of cotton with 21 percent turnout includes approximately 700 lb of foreign matter. Turnout normally ranges from 15–26 percent for cotton strippers. The foreign matter in stripped cotton consists of burs, sticks, and fine trash, which generally consists of fine leaf trash and soil particles. During the ginning process, sticks and fine trash are more difficult to remove than burs. Also, sticks may include bark, which can contaminate the lint and result in grade reductions and losses of $20–$25/bale. Bark contamination occurs somewhere between the removal of bolls from the plant and the separation of lint and seed at the gin stand. Environmental conditions, production practices, preparation of plants for harvest, and stripper operating parameters affect the incidence of bark contamination (Brashears 1980).

Stick content and grade reduction due to bark contamination can be minimized by reducing the aggressiveness of the stripper rolls. Strippers are less aggressive when the synchronization of the rolls is paddle-to-brush rather than paddle-to-paddle. The aggressiveness of stripper rolls can be further reduced by reducing the width of the paddles. Stick content and fine trash material can be reduced by harvesting with the stripper rolls spread as wide as possible while minimizing the harvesting loss. Fine foreign matter can also be reduced by operating the stripper rolls so that they barely touch the soil surface (Brashears 1984). Operating the stripper at speeds higher than 5 miles/hr has been shown to increase stick and bark content and decrease the grade of the cotton.

Environmental and plant conditions prior to and after a killing freeze and during the growing season appear to have a significant effect on the cotton grade resulting from bark contamination. In plants with high moisture due to high rainfall, freeze causes the phloem fibers to swell and burst. This bursting results in more bark being removed during harvest. Dry conditions after a freeze enhance the drying of the cotton plant, so the plant becomes very brittle; and sticks are then easily removed at harvest (Brashears 1989). When feasible, desiccants may be used to kill the entire plant, and stripper harvest should be delayed 8–10 days to avoid grade reduction due to excessive bark.

Some harvesters are equipped with field cleaners or extractors that are similar to stick or bur machines used as precleaners in the cotton gin. These units are capable of removing 60–70 percent of the foreign matter and can thus reduce the amount of trash that must be handled at the cotton gin. Although the field cleaners improve the grade, the economics of these systems is primarily gained through lower ginning costs. Brashears and Baker (1988) have shown that the factory-installed field cleaners can pay for themselves in 800–1,000 bales if ginning costs exceed $2.50/hundred weight.

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Seed Cotton Storage and Handling

William F. Lalor, M. Herbert Willcutt, and Robert G. Curley

Since 1972, there has been a steady increase in the use of modules for storing harvested cotton. By 1992, more than half of the U.S. cotton crop was stored in modules before ginning. A cotton module is a freestanding stack of cotton; the stack is produced by dumping harvested material into a form known as a module builder. A module builder is equipped with a mechanism that compacts the harvested material to a density of about 12 lb/ft^3, thus giving the stack integrity to be freestanding after the module builder is removed. Specially built, self-loading trucks and trailers are used to transport the intact modules.

The purpose of the modules is to provide reservoirs where harvested cotton may be stored when it cannot be ginned immediately, permitting the harvesting operation to proceed independently of ginning. Gins can draw from the reservoir during periods of bad weather when harvesting is not possible. Having a supply of cotton leads to a more predictable, manageable, and economical operation.

Before module use became common, cotton was usually stored in trailers. The cost of owning numerous trailers limited the amount of storage, and harvesting was frequently delayed when the trailers were full.

Dumping seed cotton on turnrows and loading it onto trailers when they became available was also used to a limited extent. Some farmers stored seed cotton on turnrows in special containers that could be loaded onto trucks because this process was more economical than buying additional trailers. The cotton ricker, which came into use in the late 1960's, was a movable slipform equipped with a compacting chamber, into which harvesters dumped seed cotton. As the ricker was filled, the seed cotton was compacted, and the slipform was moved forward to create room for additional cotton. The end product was a compacted, freestanding cotton stack of length determined by the operator.

The Arkansas Cotton Caddy was the first device to make a compacted, freestanding stack of harvested cotton used for both storage and transport. The floor of the caddy served as a pallet, making it possible to reload the stack into the caddy for transportation to the gin. In 1971 an enlarged, mechanized version of the Arkansas Cotton Caddy was developed that used a new system for handling materials. This new system has since become known as the module system of seed cotton storage.

Module builders, in two sizes (24 ft or 32 ft long), became commercially available in 1972. In the original module system, pallets made from metal or wood were used and were positioned on the turnrow; the module builder was then towed into position over the pallet. When a module was completed, the rear door was opened and the builder was raised, drawn forward, and positioned over another pallet. The pallet of cotton was later winched onto a specialized trailer and hauled to the gin. It was believed that the pallet was needed to preserve the integrity of the stacked mass during loading and unloading and to provide protection from ground moisture. Shortly after its introduction, the module system was successfully used without pallets by stacking cotton directly on the ground and picking it up later with a self-loading trailer.

The American Society of Agricultural Engineers Standard S392 reflects the industry's consensus on the essential features and dimensions of a module builder. Although 24-ft-long module builders are still acceptable, only 32-ft-long models are now manufactured. Stripper-harvester models are 2 ft higher than spindle-picker models. Some module builders with nonstandard dimensions are in use. It is possible to make a module of a weight that exceeds permissible highway-department limits when using any 32-ft module builder, especially a nonstandard one. In general, modules should not weigh over 21,000 lb.

Various types of trucks, highway tractor-trailers, and farm tractor-trailers are available for loading and hauling modules on public roads. On gin yards, specialized movers are used to move modules from storage to the gin. The highway transporters and the gin-yard movers are designed to easily transfer modules onto the feeder platform. Another specialized loading device, known as a straddle loader, is capable of picking up a module, elevating it, and placing it on a flatbed truck or trailer. Straddle loaders are also used to unload modules from trucks or trailers and to move modules from their storage location on the gin yard to the module-feeder platform.

Application

Experience across the Cotton Belt has shown that the storage of seed cotton in modules can benefit growers and ginners when the harvesting rate for the gin community is greater than the ginning rate and when there is sufficient volume to justify the investment. Trailers are an efficient, inexpensive method of delivering cotton to the gin, but they can become expensive if used for seed cotton storage.

Growers and ginners must make a joint decision whether or not to use the module system. The gin must be equipped for module storing and handling. Roads and bridges to be used by module trucks must be able to handle gross loads up to 50,000 lb.

Quality Changes During Storage

Several variables affect seed and fiber quality during seed cotton storage. Moisture content is the most important. Other variables include length of storage, amount of high-moisture foreign matter, variation in moisture content throughout the stored mass, initial temperature of the seed cotton, temperature of the seed cotton during storage, weather factors during storage (temperature, relative humidity, rainfall), and protection of the cotton from rain and wet ground.

Study results provide useful guidelines on how storage variables affect quality. These results clearly show that, while it is impossible to predict precisely how storage variables will affect quality, guidelines for safe, effective storage are useful.

Lint Quality

Early research by the U.S. Department of Agriculture on quality changes during seed cotton storage involved storage in bins, trailers, and bales. Prestorage treatments included various levels of drying and cleaning. In-storage treatments included aeration and drying. These studies examined the importance of moisture, trash, temperature, and length of storage on both lint and seed quality. The lint withstood higher levels of moisture than the seed before losing quality. Before this research it was considered impractical to dry or aerate seed cotton to preserve quality during storage. The recommended procedure was to use good harvesting practices and store only low-moisture seed cotton.

Oklahoma researchers stored machine-stripped seed cotton in bales made with a gin press. They studied the effects of density, cleaning and extraction, moisture content, and length of storage. Results show that seed cotton can be stored safely in high-density bales (25 lb/ft^3) if certain precautions, especially in relation to moisture, are followed. Some yellowing of the lint was noted in lots with seed cotton moisture levels above 10.5 percent, although the amount of yellowing was not statistically significant. No heating occurred in bales with initial moisture levels of 12 percent or less.

Research in central and south Texas shows that some light spotting occurs in seed cotton stored at a moisture level of 13–15 percent. A comparison of grades between cotton stored in modules and in trailers shows no significant differences at 11–13 percent moisture. California studies indicate that changes in both temperature at harvest and average ambient temperature during storage have a moderate effect on yellowness. Moisture content, on the other hand, caused yellowness to increase sharply at levels above 13–14 percent, especially when the storage period exceeded 45 days. For long storage periods, moisture should be below about 12 percent.

Yellowing is accelerated at high temperatures. Both temperature rise and maximum temperature are important. Temperature rise is probably more related to the heat generated by biological activity than to heat gained from the environment. Seed cotton moisture of 12 percent or less will allow safe, long-term storage, assuming that production, harvesting, and storage guidelines are followed. Higher seed cotton moisture can be tolerated for short storage periods. The rate of lint yellowing, however, begins to increase sharply at moisture above 13 percent and can increase even after the temperature of a module drops.

Seed Quality

When seed cotton is stored, the length of the storage period is important in preserving seed quality and should be based on the moisture content of the seed cotton. Seed quality is sacrificed (germination is reduced and free fatty acid content and aflatoxin level are increased) if the relationship between moisture content and storage length is not understood. The box on the right shows recommendations from Agricultural Research Service (ARS) studies on safe storage. The studies were done on small lots of seed cotton at densities up to 12 lb/ft^3.

Moisture content of seed (percent, wet basis)	Maximum safe storage (days)
8–10	30
10–12	20
12–14	10
14–15	fewer than 3

The following are important considerations when storing seed cotton:

1. There is a lot of variability in the moisture content of seed cotton and cottonseed within modules.
2. The seed moisture generally increases 1 or 2 percent during storage, especially with seed cotton stored at the higher moisture levels.
3. The quality of the seed, as indicated by germination and free fatty acid, is not affected if the seed moisture does not exceed 11 percent during storage.

4. Seed of low quality at harvest continues to lose quality in storage regardless of moisture level.

5. The amount of trash and its moisture content are critical factors in storing seed cotton.

6. A combination of long storage periods and warm ambient temperatures produces poor germination.

7. Seed can be physically damaged if seed cotton is compressed to a density of 25 lb/ft^3.

Seed cotton moisture content during storage is the most important variable affecting seed germination and oil quality. A general, conservative recommendation is that seed cotton moisture should not exceed 10 percent for module storage when the seed will be saved for planting. Oil quality, on the other hand, appears to be less sensitive and can be preserved at 12 percent moisture content during storage.

Operational Guidelines

Harvest Management

The output of a typical 32-ft, picker-type module builder can reach 15 bales/hr but averages 11–13 bales/hr. Modules vary in height and weight but they typically contain 10–14 bales of picked cotton (in picker-type modules) or 8–10 bales of stripped cotton (in stripper-type modules).

The optimum number of harvesters per module builder depends on crop yield, row length, and operator proficiency. Too many harvesters per module builder can result in inefficiency caused by the inability of the module builders to keep up. Too few harvesters results in underutilization of the module builders. Six picker heads or six to eight stripper heads per builder is a good ratio.

Module-hauling trucks are expensive to own and operate. High annual usage is necessary in order to keep costs low. Therefore, many gins own trucks and haul modules for their customers. In some cases, custom harvesters own module builders and trucks and will make and handle modules for growers.

Moisture Monitoring

If seed cotton is to be stored safely without harming lint or seed quality, it should be harvested at a moisture content below 12 percent and should contain a minimum of green trash. Water added in the picking process can also be a significant factor in creating an excess moisture condition.

Ideally, growers should monitor seed cotton moisture before and during harvesting so that they can prevent the creation of high-moisture modules either by delaying harvest or by ginning the cotton immediately before there is loss of fiber quality. In a module, temperature increase is an after-the-fact indicator of excessive moisture and of possible quality loss that could have been avoided. Routine moisture measurements with a meter are important, particularly early and late in the day when moisture levels are highest. Portable moisture meters should be periodically calibrated according to manufacturer's procedures to ensure that they are reading correctly. When meters are used, samples should be representative of the machine-harvested (not hand-harvested) material. The meter should be clean and dry, and the samples should be mixed by hand (preferably while wearing latex gloves) to mix any surface moisture into the seed cotton. Each sample should be stuffed firmly into the meter cup.

Moisture readings should be taken two or three times per sample and the readings averaged. Between readings, the sample should be removed from the meter and mixed. Latex gloves should be worn when handling seed cotton, since moisture from hands can get onto the fiber and give false readings.

When modules are being made, it is possible to automatically monitor and record the moisture content of each by using a meter mounted on the module-builder tramper foot. A reading is taken in the compacted cotton each time the ram reaches the bottom of its stroke. Readings are stored in a computer that determines average and maximum moisture content of the module.

Site Selection for Module Storage

A safe storage site for modules should be

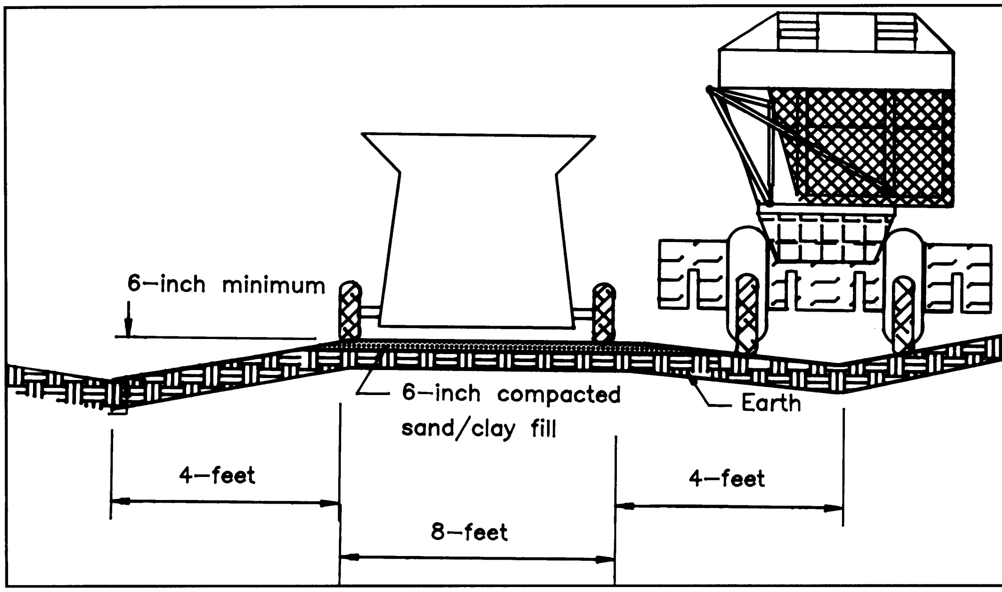
1. Well drained
2. Free of gravel, stalks, and debris such as long grass
3. Smooth, firm, and near-constant grade
4. Accessible in wet weather
5. Away from heavily traveled roads and other possible sources of fire and vandalism
6. Clear of overhead obstructions such as power lines.

Growers may use turnrows, field roads, or designated in-field storage areas as storage sites for modules. Field turnrows can be improved by preparing an elevated site (fig. 2–1). Drainage precautions are essential because standing water or permanently wet soil will cause a layer of seed cotton to deteriorate. In the Rain Belt, modules should be oriented north-south because they dry faster after rain than when oriented east-west.

Building a Good Module

The module-builder operator should have no other responsibilities and should have authority over when and where the harvesters dump the cotton. When the module is being built, two workers are required to service the harvesters and to cover the modules.

Figure 2–1. Turnrow profile for seed cotton module



Harvesters must be scheduled so that only one dumps at a time. The first and second dumps should be made in opposite ends of the builder. The third dump should be made near the middle, and leveling and compacting should begin immediately and continue until the module is completed. Automated compacting systems are available to save labor and will pack the seed cotton tightly. The tighter the module is compacted, the better it sheds rainfall from the sides and the less seed cotton is lost during storage, loading, and hauling. The final dumps should make the module look like a giant rounded loaf. If the module is properly shaped and covered with a tarp, water will be shed by the cover. If depressions occur in the tarp, water will collect in them and cause serious problems.

Tender Trailers
Self-dumping tender trailers can increase harvester efficiency by reducing travel and dumping time. These trailers can be placed at both ends of the field so that harvester dumping is possible at either end. Tender trailers can be used to hold and transport cotton while a module is being topped off or while a module builder is being moved, thus enhancing the effective daily capacity of harvesters and allowing modules to be built on high ground away from the picking area. If modules can be stored on the turnrow near the site where pickers would normally dump, the same advantages can be achieved with a second module builder for about the same cost.

Covering Modules
When a module is completed, it should be covered with a high-quality tarpaulin. Tarpaulins should be purchased well ahead of when they are needed, and brands that are not labeled with the manufacturer's name and telephone number should be avoided.

Tarpaulins made from cotton permit moisture vapor to escape and are therefore less likely to trap condensation from within the module. They should be tied with some give in the ties so that shrinkage will not damage the tarpaulin. Finished dimensions of cotton tarpaulins should be 6 ft wider and 8 ft longer than the module to adequately cover the top edges and to allow for shrinkage. If a module is properly located, packed, and covered and is stored in a dry place, it requires no additional protection, just continued monitoring.

Cotton tarpaulins should be checked for leakage with the following simple ponding test, especially after one or more seasons of use: Lay the tarpaulin over a bucket (about 1-ft diameter), form a depression, and fill the depression with water. After an hour, if more than one drop per minute leaks through, waterproof the tarpaulin before use. Check the strength of the fabric to be certain that it has not deteriorated.

Synthetic tarpaulins are lighter, less costly, and generally easier to care for than cotton tarpaulins. Because synthetic materials trap moisture, however, precautions must be taken to prevent seed cotton quality losses from occurring due to condensation. The primary precaution is to ensure that cotton is not stored damp because the condensation comes from moisture in the stored cotton.

All tarpaulins should be tied securely to the module to resist expected winds. Placing straps on the ground under the module is a secure tie-down method; the straps should be made of cotton, be removed before loading, and never be cut. Other tie-down methods are preferable because of the risk of contaminating the cotton if a strap enters the gin. The recommendations of the tarpaulin manufacturer should be followed.

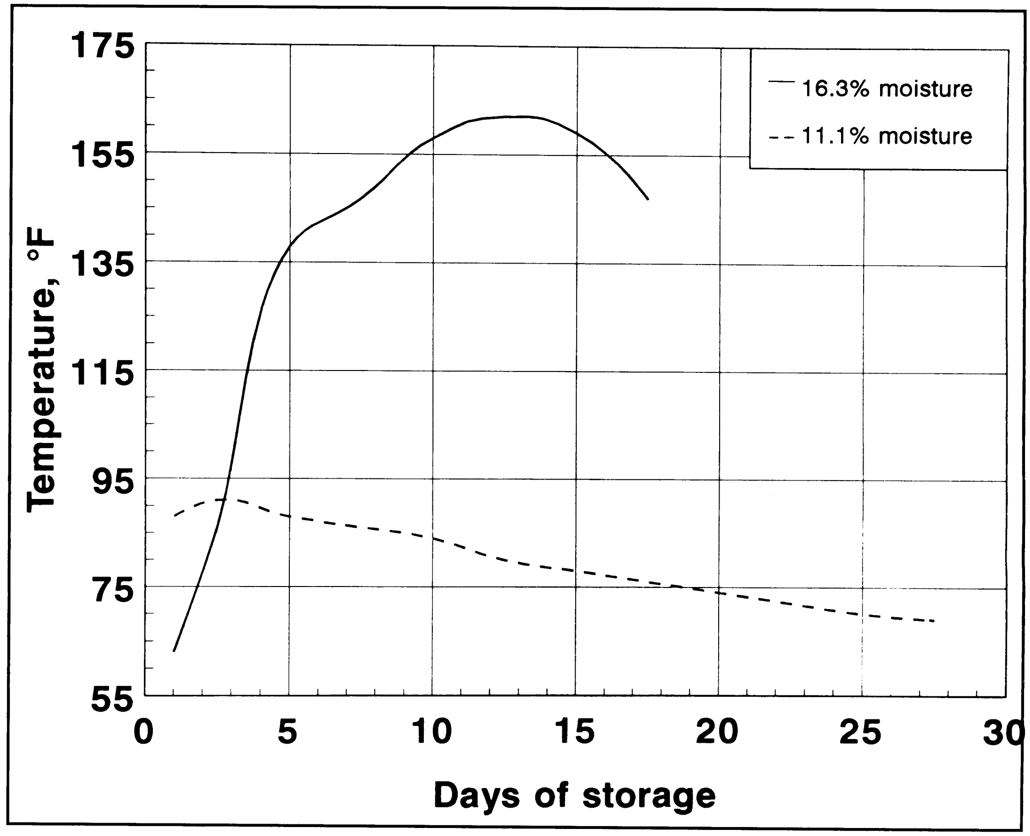
Monitoring Module Temperature During Storage

Module temperature should be checked in at least six locations on a daily basis for the first 5–7 days. Beyond that time, the probing can be done every 3–4 days or as the temperature dictates. The temperature probe should reach at least 2–1/2 ft into the module. Figure 2–2 shows a typical temperature chart from modules stored at two moisture contents.

Modules that are harvested at safe storage moisture will generally not increase more than 10–15 °F during the initial 5–7 days and will then level off and even cool down as storage continues. A rapid and continuing rise in temperature of 15–20 °F or more during the first few days generally signifies a moisture problem. If a temperature of 120 °F is reached or if the temperature increases by more than 20 °F, the module should be ginned immediately to avoid the possibility of major loss. Unless ginned immediately, high-moisture modules (especially those harvested late in the season when ambient temperatures are low) may continue to increase in temperature at a slow rate over a period of several weeks.

All modules should be inspected weekly and immediately following storms to detect damaged or missing tarps, water ponds in depressions, or leakage of

Figure 2–2. Typical temperature rise as a function of seed cotton moisture content and days of storage



rainwater through the tarps. Water ponded in depressions in the tarp, regardless of tarp material, should be drained off. If water has leaked into the module, the modules should be ginned as soon as possible. Inspection should also include checking for excessive surface water or wetness near the base of the modules and for any theft or vandalism.

Safety

The module builder is a simple implement. Operators should refer to the operators manual for safety instructions relating to each specific module builder. A partial list of safety items is shown below.

1. Keep out of the machine when it is in use.

2. Keep away from the top of the module builder and the compactor bridge when the unit is operating. The operators platform is the only safe place for viewing the operation.

3. Do not work on the machine while it is operating or operate the machine with chain guards or hose shrouds removed.

4. Be certain that people and vehicles are clear of the tailgate when it is being opened or closed.

5. Never operate the unit close to electric lines.

6. Read, understand, and fully follow your operators manual instructions concerning preparation of the module builder for transportation between fields or over the road.

7. Never reach under a raised module builder. This is especially important for those who place tarp ties under the module builder just after moving it to a new location.

8. Do not smoke or use welding equipment around a module builder that contains cotton.

9. Check and repair damaged hydraulic hoses before they burst. Use paper, not your hand, to check for leaks in a system that is under high pressure.

Economics of Gin Operation

O.A. Cleveland, Jr., and William D. Mayfield

The U.S. cotton industry is characterized by a continuously changing economic environment driven by technological advances and the substitution of mechanical labor for manual labor in the producing and marketing sectors. Further economic change has resulted from geographical shifts in production and the influence of government programs.

The need to improve the efficiency of ginning is evidenced by the fact that the cost of ginning represents a major cost in moving cotton from the farm to the mill (Shaw et al. 1977). The estimated percentages of the cost associated with processing cotton are shown in the box on the left.

Component	Percent of total cost
Assembly seed cotton	10
Ginning	38
Warehousing	15
Merchandising	37
Total	100

Efficient gin plants make money for their customers; inefficient gins lose money. Efficient gin operations provide cotton growers with two benefits: (1) they increase the net return to the grower and (2) they help cotton remain cost competitive with synthetic fibers.

Ginning Costs

Cotton gins, like any independent business, face a cost schedule that can be divided into fixed costs and variable costs (Anthony and Mayfield 1984). Fixed costs accrue regardless of the number of bales ginned. That is, even if the gin did not operate 1 yr, these costs would still be incurred. Annual fixed costs include depreciation, interest on investment, property insurance, and property taxes. Typically, the costs of management and permanent labor are also considered fixed.

Variable costs are dependent upon the number of bales of cotton ginned. Primary variable cost items are seasonal or temporary labor, electrical energy, fuel energy (natural gas or propane), bagging and ties, and repairs. Of lesser importance are the costs of office supplies, advertising and promotion, and travel. The variable labor costs are usually subdivided into costs of gin labor and office help.

Economies of Size

A primary problem confronting gin facilities is the need for increased volume. That is, most gins process a smaller volume of cotton than they are capable of handling. Thus fewer bales must absorb the total fixed costs, causing per bale ginning cost to increase. Higher annual ginning volume allows the fixed costs to be spread over a larger number of bales, thus reducing the per bale fixed costs and resulting in a more complete utilization of facilities.

Theoretically, output of gins of a given size can be increased either by ginning at a faster rate or operating over a longer period of time. However, since ginning systems prohibit increases in ginning rates, except for brief periods, the volume ginned can only be increased by increasing hours of operation. For ginning time to be increased, gin plants must have sufficient volume to operate throughout the full season. In response to increased operating hours, the total cost of ginning increases linearly; however, the average total cost per bale decreases nonlinearly until gin output reaches maximum capacity.

As volume increases beyond certain levels, so must gin size increase for the operation to remain efficient. However, gin size must not be increased before volume increases; otherwise, costs per bale would increase due to high fixed cost. The effects of gin size and volume on ginning cost for gins of fixed size are shown in table 3–1. Note that for a given gin size (gin size is expressed in terms of total investment) the greater the volume the lower the total average cost per bale. However, also note that as gin size increases, the volume required to lower gin cost increases at a faster rate. Although the actual cost of ginning cotton changes with inflation and adjustment of all input costs, the effects of gin size and volume remain unchanged. The data in the table was based on 10-yr life, 10-percent salvage value, and 10-percent annual interest; additionally, the data was based on taxes and insurance equaling 0.95 percent of investment and total variable costs equaling $23/bale.

Gin Modernization

Most gins constructed over the past few years offer advantages such as equipment for automatic unloading and for bale covering and strapping. Further, these gins are equipped with a universal density press; therefore, the bales produced in these gins do not require additional compression after leaving the gin.

Such modernizations, while allowing reduced ginning costs, place additional pressure on gin management. This automated equipment adds geometrically to the investment cost. Thus, it becomes imperative for gins to have a stable volume of cotton.

Cost of Ginning

The most important cost components of ginning are depreciation and interest, accounting for some 30 percent of the typical gin's total costs (Cleveland et al. 1987). These two fixed costs may be about the same, but typically, depreciation is larger. On a per bale basis, however, total variable cost usually exceeds fixed cost.

Gin labor, bagging and ties, and electrical energy are the largest variable costs (Anthony and Mayfield 1983). Gin repair also accounts for a significant portion of variable cost. However, today's more efficient gins operate with

Table 3–1.
Influence of gin size and annual volume on average per bale ginning cost, 1988 base year

Gin size (millions of dollars invested)	Volume (bales)	Average cost per bale (dollars)
0.5	2,000	70.25
	3,000	54.50
	4,000	46.63
	5,000	41.90
	6,000	38.75
	7,000	36.50
1.0	4,000	67.75
	6,000	52.83
	8,000	45.38
	10,000	40.90
	12,000	37.92
1.5	8,000	59.06
	10,000	51.85
	12,000	47.04
	14,000	43.61
	16,000	41.03
2.0	9,000	62.91
	12,000	54.92
	15,000	48.53
	18,000	44.28
	22,000	40.02
2.5	10,000	69.95
	14,000	56.54
	18,000	49.08
	22,000	44.34
	28,000	39.77
3.0	10,000	78.70
	15,000	60.13
	20,000	50.85
	30,000	41.56
	40,000	36.93
	50,000	34.14
4.0	15,000	71.40
	20,000	59.30
	25,000	52.04
	30,000	47.20
	40,000	41.15

Cost	Percent of total[1]
Fixed costs:	
Depreciation	16
Interest	15
Insurance	2
Taxes	3
Management	8
Permanent gin labor	2
Permanent office labor	2
Total fixed cost	46
Variable costs:	
Office help	1
Gin labor	15
Dryer fuel	4
Electrical energy	10
Bagging and ties	11
Repairs	9
Miscellaneous	4
Total variable cost	54
Total fixed and variable cost	100

[1]Numbers in column were rounded and therefore may not sum to the total.

fixed cost representing about 35–40 percent of the total rather than the more typical 46 percent. The estimated annual fixed and variable costs per bale, expressed as a percentage of total unit cost, for 1988 are shown in the box on the left.

Other Considerations

The continuously changing economic environment increases the risk to ginning operations. Government programs, water requirements, insect control, and the global economy impact the location of cotton production and the yield of cotton. The above factors, and others, directly impact the profitability of ginning operations.

More so than in many other businesses, customer relations are a measure of the gin's future. Gin management must constantly strive to meet producers' needs but in doing so may sacrifice efficiency. Some producers may not be as concerned with efficiency as they are in feeling that they have control over the gin process. In the final analysis, gin management is the true key to success.

Implications and Considerations

Analyses indicate that cost savings in the ginning operation exist for larger gins. More importantly, however, the estimates indicate that a more substantial savings could be achieved if gins could be assured the volume necessary to operate for a longer period of time than most presently do. These savings are a result of greater utilization of gin machinery and equipment as well as management and labor skills. Average costs are lower for extended operations because fixed costs may be spread over a greater volume.

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Gin Management

William D. Mayfield, Charles Owen, and Hugh H. Summerville, Jr.

A cotton gin, like any business, must make a reasonable profit for its investors. For the gin to do so, a quality and reliable service must be provided or customers will go to competing gins and volume will be reduced to an unprofitable level.

The primary service that a gin must provide is to maximize the value of the seed cotton in a timely manner. For the gin to do so, management must be familiar with ginning technology and the gin must be equipped to do the best job for growers. Management must also have sufficient knowledge of cotton ginning and marketing to evaluate the quality potential of cotton and to balance the market premiums and turnout to determine the best way to gin cotton.

The owners or board of directors should set the policies of the gin. The manager, with the concurrence of the owners, should establish the specific objectives. When the policy and the objectives are agreed upon, owners and managers must be completely committed to them.

A major responsibility of gin managers is to build and maintain good customer relations. Customers deserve value for the fees paid for ginning, and they also expect to be treated with respect and appreciation. To maintain good relations, some gins serve as meeting places for customers; others maintain good relations simply by providing outstanding services at a reasonable cost. Typically, producers use gins as communication centers to exchange information on production, markets, and weather. Gins can keep their producers informed on industry concerns such as contamination, environmental regulations, and textile industry trends.

Gin managers should always be aware of any misunderstandings, concerns, or problems that customers may have and should be able to discuss these situations at the customer's convenience. Often a little concern shown early can keep a small misunderstanding from growing into a major problem.

Gin managers should be familiar with cotton production and with textile uses for cotton of various qualities. They should be familiar with the fiber evaluation system and be able to explain in general terms why various quality factors are important. A well-informed ginner can help growers make profitable production decisions and can improve the performance of textile mills.

Employee Relations

The gin manager should be in charge of screening, hiring, and training all employees. The manager may elect to allow someone to perform these jobs but must ultimately be responsible. The many Federal, State, and even local regulations that govern gin employees must be closely followed.

The gin manager should be responsible for building good team attitudes and relationships among employees. Employers should let employees know that they are important to the success of the gin and should tell employees that the goal is to keep them happy and healthy. Employees should be told that they are indirectly responsible for helping protect the safety of the other team members, including management, owners, and customers. If the employees believe that they are a part of a caring team, they will be more productive.

Employers should provide an incentive to employees who are productive and dedicated and who contribute to the success of the business. If it is practical, employees should be rewarded according to their contribution. Bonuses can be built into wages based on individual productivity (if it can be measured), or employees can be rewarded as a team. Recognizing employees in front of their friends is a very effective and inexpensive reward process.

Safety Programs

Safety is very important for cotton gins. Management and owners must be totally committed to safety to have a good program and a good long-term safety record. Every person has a basic moral responsibility to help protect the health and happiness of others, especially if that person employs or supervises the others.

Gins that are safety conscious are also more economical. Safe gins are more productive and have lower insurance costs. In each State, workers' compensation rates are directly affected by the frequency and severity of gin accidents. Most States allow insurance companies to adjust a gin's individual workers' compensation insurance rate.

Materials and guidelines for developing a safety program specifically for a gin can be obtained from the nearest regional cotton ginners' association or from the National Cotton Ginners' Association.

Machinery Management

Gin management must assure that the gin plant is equipped with machines that will maximize the value of the seed cotton received. When it is anticipated that the system will be modified or expanded, the manager should, with the help of machinery suppliers and other appropriate sources, make recommendations to owners concerning machinery purchases and installations. All expenditures must be justified on the basis of their projected return on investment or improvements in service.

A thorough off-season maintenance and repair program is essential for a gin to be productive and profitable. Ginning is so seasonal and competitive that a major breakdown during midseason can reduce annual volume enough to eliminate profits for the year. A good supply of spare parts should be kept at the gin. Each gin should have a list of things to check on each machine during off-season repair. A repair log for each machine is valuable to help decide when repairs are needed.

In-season repairs and maintenance are also critical. On each work shift, time should be allowed for shutting the machinery down, cleaning it out, lubricating it, and checking for and correcting problems before they get bigger.

The manager should be aware of the effects of processing rates and other conditions on performance of various machines in the gin. Ginners should be instructed on items such as expected processing rate, settings, lint cleaner combing ratios, and target moisture contents or drying temperature settings. The manager must consider the effects of drying and ginning on fiber quality and value and must balance such effects with the gin's energy costs.

The manager is responsible for determining the order in which trailers or modules will be ginned. If possible, seed cotton should be "blocked"—that is, cotton belonging to the same owner and being similar in trash content and moisture should be ginned together.

The manager is also responsible for housekeeping in and around the gin. A clean, well-organized gin is safer and more productive, encourages pride in employees, and helps reduce the frequency of lint contamination.

Federal Labor Laws

Fred Johnson, Robert Tucker, and K.B. Smith

Cotton gins, like most businesses, must comply with a number of Federal labor laws. While ginners are usually considered agricultural employers and are exempted from some Federal regulations, they must still pay close attention to all Federal statutes and know what is expected of them.

The following is a summary of the major Federal labor laws affecting cotton ginners. These laws can be changed or altered by Congress, so a careful, periodic review of these regulations by employers is recommended.

For more detailed information on these laws, gin employers should consult the references in this section and contact the appropriate regulatory agencies or their ginners' association.

Minimum Wage and Overtime Provisions

The Fair Labor Standards Act (FLSA) establishes minimum wages and maximum hours allowable without overtime pay. The law contains several agricultural exemptions, one of which applies to cotton gins. This exemption allows cotton ginners to pay the regular hourly rate to gin employees working up to 10 hr/day or 48 hr/week for 14 weeks/yr (U.S. Department of Labor 1986).

Each employer subject to FLSA provisions is required to maintain records of the wages, hours, and other employment conditions and practices for every employee. The administrator or a designated representative of the Wage and Hour Division of the U.S. Department of Labor may enter a gin and inspect the employment conditions, practices, and employment records and may conduct any investigation deemed necessary to determine whether violations have occurred (Runyan 1989).

Occupational Safety and Health Standards

The Occupational Safety and Health Act was enacted in December 1970 to assure safe and healthful working conditions for working men and women. It also established the Occupational Safety and Health Administration (OSHA). U.S. Department of Labor regulations require every employer, unless specifically exempt, to follow OSHA standards. The OSHA establishes specific duties for employers in a "General Duty Clause." The employer's duty is to furnish each employee with a workplace that is free of recognized hazards that have caused or are likely to cause death or serious physical harm (U.S. Department of Labor 1988). It is also the employer's duty to comply with OSHA standards established in the law. It is the employee's duty, under the law, to comply with those standards and with all rules, regulations, and orders that have been issued after the law's passage and that are applicable to employee conduct (Runyan 1989).

Agricultural employers are subject to a number of OSHA standards and provisions, including those for temporary labor camps, anhydrous ammonia storage and handling, roll-over protective structures, slow-moving vehicles, guards for farm equipment and cotton gins, and hazard communication (see 29 CFR, 1992 ed., 1928.21).

OSHA requirements for guards in cotton gins are summarized in this book in "Safety and Health of Gin Workers" in section 11 (see figs. 11–1 and 11–2). Details and a sample program for the hazard communication standard are covered in "Hazard Communication: A Program Guide for Cotton Gins" (National Cotton Ginners' Association 1988). Other pertinent OSHA provisions require employers to inform employees of the Occupational Safety and Health Administration's obligation to protect employees. Employers are also required to notify OSHA within 48 hr of any accident resulting in a fatality or hospitalization of five or more employees. Also required are annual summaries of occupational injuries and illnesses. These records must be kept for 5 yr (U.S. Department of Labor 1989).

OSHA is authorized to conduct workplace inspections to assure compliance with the law. Safety and health officers, upon presenting appropriate credentials, are authorized to enter a workplace without delay and at reasonable times. Most inspections are conducted without advance notice and usually place special emphasis on posting and record keeping (U.S. Department of Labor 1989).

Migrant and Seasonal Agricultural Worker Provisions

The Migrant and Seasonal Agricultural Worker Protection Act (MSPA), passed in 1983, is the only major labor law dealing strictly with agricultural employment. The act provides migrant and seasonal farm workers with assurances about pay, working conditions, and work-related conditions (Runyan 1989).

Under the law, farm labor contractors and their employees who contract out farm labor must obtain a certificate of registration from the U.S. Department of Labor before they perform such contracting. In addition, farm-labor contractors, agricultural employers, and agricultural associations must disclose to migrant and seasonal workers information about wages, hours, and other working conditions and about housing, when provided. Migrant and seasonal workers must also be provided with written statements of earnings and deductions. Vehicles used for transporting migrant and seasonal workers must be safe and properly insured, and housing, if provided, must meet safety and health requirements (see Public Law 97–470, Jan. 14, 1983).

For agricultural employers and agricultural associations that use a farm-labor contractor, the law requires them to take reasonable steps to determine whether the contractor has a valid certificate of registration. In addition they must save wage records received from contractors for 3 yr (see Public Law 97–470, Jan. 14, 1983).

MSPA designates both criminal and administrative sanctions against anyone who violates the law. The law also permits anyone aggrieved by a violation of any of the law's provisions to file suit in Federal District Court (Runyan 1989).

Immigration Provisions

The Immigration Reform and Control Act of 1986 (IRCA) was passed to control unauthorized immigration into the United States. Employer sanctions and increased appropriations for enforcement are the main ways of accomplishing the law's objective. The employer sanctions provision in the law designates penalties for employers who hire aliens not authorized to work in the United States. An amnesty provision in the law allowed illegal aliens who lived continuously in the United States before January 1, 1982, to apply to the Immigration and Naturalization Service (INS) for legal resident status by May 4, 1988—the application cutoff date.

The provision of IRCA having the greatest effect on agricultural employers is employer sanctions. Under this provision, all employers are required to verify that each employee hired after November 6, 1986, is eligible to work in the United States. Verification must include completing INS Form I–9. Before completing this form, the employer must examine documents that establish the employee's identity and eligibility to work in the United States.

Producers of perishable agricultural crops, as defined by the Secretary of Agriculture, were exempt from employer sanctions until December 1, 1988. This exemption was granted under the Special Agricultural Worker (SAW) Program of IRCA. The law includes a provision for a Replenishment Agricultural Worker (RAW) Program to help meet labor shortages that were not solved by the SAW program. The Secretaries of Agriculture and Labor are authorized to determine whether the RAW program will go into effect each year (7 CFR, 1992 ed., Subtitle A, le.1).

The H–2A program, another provision of IRCA, allows employers who are anticipating a shortage of domestic workers to apply for permission to bring in nonimmigrant aliens for temporary or seasonal agricultural work. Approval, however, will not be granted unless a number of recruitment and employment conditions are satisfied first (20 CFR, 1992 ed., 655.100).

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Gin Insurance

Fred Johnson, Daniel Moore, Tomy Smith, and Ronald Gleghorn

Cotton ginners have a large investment in expensive and sophisticated structures, machinery, and vehicles. In addition, they are responsible for transporting, storing, and processing farmers' cotton. Ginners also employ a diverse work force and must ensure the safety and health of workers on the job. In order to protect the business from possible loss and from expensive litigation, a ginner must make informed decisions when purchasing insurance.

The purpose of this article is to show ginners what types of insurance are available and to give a summary of each. Since insurance policies can vary in coverage, terms, and requirements, ginners are advised to contact their insurance agent for more specific information.

Property Insurance

Property insurance covers all facilities, contents, machinery, and inventory that are owned, leased, or cared for by the ginner. Coverage for gin buildings and machinery is obtained by filling out separate property forms. Using these forms, the ginner can choose specific coverage by individually listing the buildings and contents to be insured and by establishing specific values for each. The ginner also has the option to choose blanket coverage in which all buildings and machinery are covered under a blanket amount or value. Regardless of the type of coverage chosen, the ginner's most important task is to estimate the cost of replacing the buildings and machinery to make sure that the coverage is sufficient. Several optional coverages are usually offered, covering such things as agricultural chemicals, fertilizers, and customers' trailers.

Ginners should read their policies carefully. Many policies have warranties, restrictions, and other requirements that must be met or the ginner can face possible cancellation of the insurance. Examples of typical requirements are having fire protection equipment in proper order and making sure buildings are used for intended purposes.

Vehicle Insurance

Vehicle insurance provides coverage for damage to gin vehicles and provides liability coverage for damage to other vehicles. Riders on the basic policy can be purchased to cover an employee's personal vehicle when used for gin business and to provide secondary coverage when an outside firm performs trucking services. It is a good practice to include all of the gin's vehicles in this policy—even trailers, chemical applicators, and spreaders.

Gin Stocks Floater Policy

The gin stocks floater policy is an "all-risk" policy to provide insurance for all cotton products while they are being transported to the gin, stored at the gin, or transported to their first destination. All-risk policies generally cover all direct losses except for items specifically excluded in the policy. This type of policy has warranties and other requirements that the ginner must meet. A typical requirement accompanying this policy includes specifications on baled cotton and seed cotton stored on the gin yard, as well as field storage of seed cotton modules.

General Liability Insurance

General liability insurance provides coverage for injuries and for product and property damage that occur on the gin's premises. Coverage only extends to nonemployees and to property not owned by the policyholder. This insurance pays up to the policy limits for sums a gin is legally required to pay. It also pays for defense costs in lawsuits on insured damages. Most policies impose restrictions on punitive damages, pollution damage, intentional acts, and damage to property in the gin's custody.

Officer's, Director's, and Manager's Liability Insurance

This type of policy provides coverage for lawsuits alleging a wrongful act on the part of one or more of the individuals responsible for running the gin. These individuals' personal assets are at risk in such lawsuits, and this type of coverage can help protect those assets. This coverage can be limited in cases where a corporation's bylaws specify that the corporation is not obligated to defend individuals and in cases where jointly owned assets are involved.

Product Liability

Product liability coverage is available to protect a ginner in the event that his or her product causes injury or damage to individuals or livestock. This type of insurance covers cotton bales and cottonseed after they leave the gin. Cottonseed is covered even if sold as animal feed.

Excess Liability Coverage

Commonly known as an umbrella policy, an excess liability policy provides additional coverage when claims exceed the limits of a gin's other liability policies. It insures against damages arising from operating the gin and its vehicles and provides further protection for employers.

Workers' Compensation

Workers' compensation insurance provides gin employees with the exact benefits set by the State where the employee is working and injured. Depending on the individual State's requirements, employees injured on the job are entitled to certain medical benefits, salary compensation for time lost from work, rehabilitation, and death benefits for survivors.

The employer's liability portion of this type of policy protects employers from most lawsuits started by injured employees and relatives.

Job-related injuries and illnesses to employees must be reported promptly to the insurer, according to the requirements of the individual State. In addition, the U.S. Department of Labor's Occupational Safety and Health Administration requires employers to prepare and maintain records of occupational injuries and illnesses.

SECTION 4—GIN FACILITIES

Site Selection, Facility and Machinery Arrangement

R.V. Baker, D.W. Van Doorn, and B.M. Norman

Companies that sell hamburgers spend millions of dollars each year looking for good locations for their facilities. The location of a business has a large bearing on business volume, operating costs, availability of workers, and profits. While location may not be as critical for a company selling ginning services as it is for one selling fast food, the location of a cotton gin can nevertheless have a considerable influence on the success of the business. It is not possible in this short discussion to cover in detail all of the techniques and involved procedures used to make intelligent site selections; however, a number of important factors that should be considered before constructing a new gin plant or remodeling or relocating an existing plant will be discussed.

Obviously, the gin should be located at a site that is reasonably accessible to its customers or patrons. This means choosing a central location within the service area on or very near a paved road. The topography and size of the site are also very important. Low-lying areas that are subject to flooding and are inaccessible during inclement weather should be avoided. Sites with high water tables should also be avoided if possible. High water tables can interfere with the construction of press and scale pits and greatly increase costs. The site should be of sufficient size to provide safe and uncongested storage yards for cotton trailers and modules. Many insurance carriers have specific requirements governing the amount of cotton that can be placed in a storage yard and the minimum safe distances between storage yards and buildings. These requirements should be identified prior to site selection and made a part of the initial selection criteria.

It is also important to remember that cotton gins discharge some dust and lint fly to the atmosphere regardless of how well they are operated. A site that is as far removed as feasible from populated areas or is downwind from a local community will greatly minimize the possibility of complaints from the local citizenry about dust, noise, or excessive traffic.

The availability of gas, water, and electrical services is also an important consideration in selecting a gin site. Local utility companies should be contacted before settling on a prospective site to find out if their services are available at that site or to determine the costs of getting these services extended to that site. It is particularly important to work with the electricity supplier not only with respect to service availability but also in order to analyze the impact of the supplier's proposed rate structure on ginning costs. It is also wise to contact the local taxing authorities to determine the tax rate and how property taxes will be assessed. If these taxes pose a significant burden, alternate sites that are taxed at lower rates or by fewer taxing entities should be considered.

The arrangement of buildings and other structures at the ginning site is often a matter of personal preference or is dictated to some extent by local customs, size and shape of the site, or location of existing public roads, etc. Consequently, no hard-and-fast rules exist for gin yard layout. Also, many cotton gins sell seed, fertilizer, fuel, or other farm supplies. The facilities required for these additional services can influence gin yard layout. The gin yard arrangement shown in figure 4–1 illustrates several layout features that have proven to be beneficial in the past and may serve as a general guide for planning purposes. The layout should include ample space for vehicle entrances and exits from a public road. Traffic control is an important consideration in that good control reduces congestion and the risk of vehicle accidents on or near the location. Ample space should be provided for customer parking near the gin office and for temporary parking and storage of loaded and empty cotton trailers and seed cotton modules. In figure 4–1 definite pathways have been established for incoming trailers and modules and for outgoing trucks hauling seed, trash, and bales of cotton. The example shows the location of the truck scales at the gin office, but in some regions these scales are located at the gin building. Also, the example includes a cotton warehouse. Obviously, not all cotton gins need their own bale storage facilities, but in some areas of the Cotton Belt it is becoming increasingly common for gins to have facilities of this type. The layout example shows that the gin building should be located so that the prevailing winds will carry

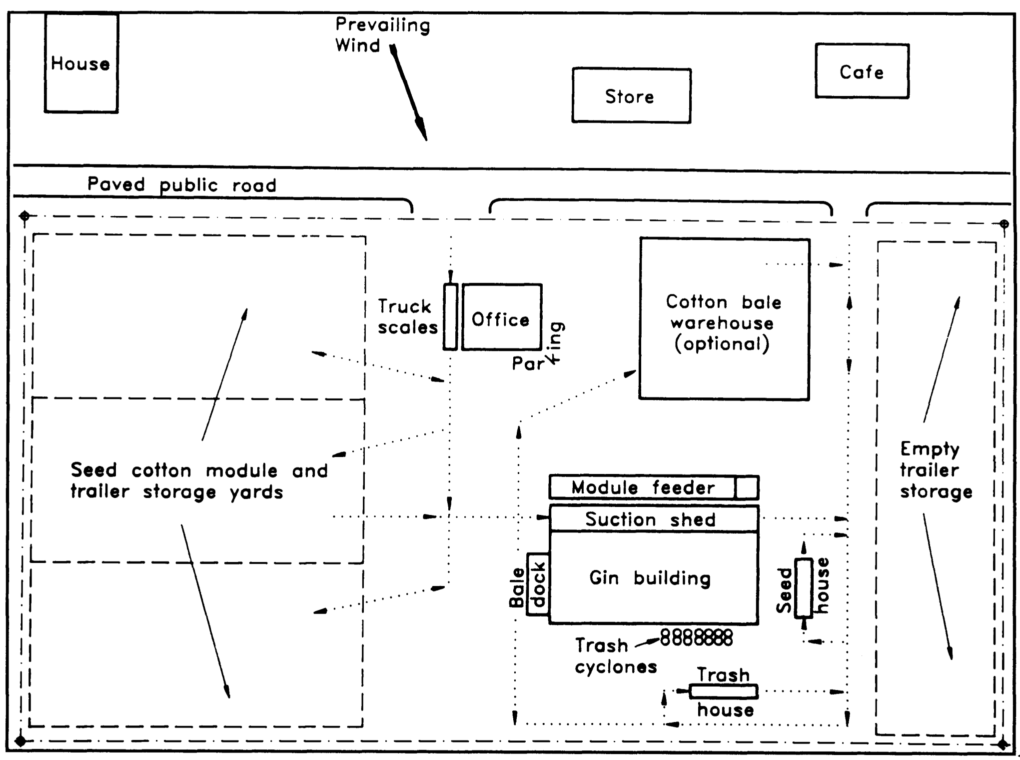


Figure 4–1. A sample gin yard arrangement illustrating desirable layout features. Dotted lines with arrows represent transportation pathways.

dust and lint fly away from the office and nearby residences and stores. Also, note that the trash collection system and bur hopper should be located downwind from the gin building. This type of layout minimizes the amount of dust drawn into the gin building by the process air and greatly improves overall gin cleanliness and the working environment of the employees.

The general arrangement of machinery within the gin building tends to be set when the gin is first constructed; thereafter changes in the arrangement are somewhat limited by the permanence of the press pit location or by below-grade trenches cast in the concrete floor. The remodeling of existing plants is often limited to replacing old machinery with newer models. While some rearrangement of the seed cotton and lint cleaning machinery is usually possible in an existing gin plant, major changes in the locations of the gin stands and press are usually difficult to accomplish without expensive alterations to the gin building. For these reasons, the initial machinery layout is very important.

The initial machinery plan for a new gin plant is usually one that has been proposed by the manufacturer of the gin machinery. This plan is usually tailored to fit the requirements of a particular gin or a given cotton growing area. Consequently, there is not a great deal of standardization in gin machinery plans. Machinery manufacturers strive to develop a plan that optimizes the overall efficiency of the gin plant while meeting the functional and operational requirements of the chosen machinery. Both the manufacturer and gin management are interested in developing a plan that encourages proper monitoring of the operating machinery and makes the machinery reasonably accessible for easy and safe repair and maintenance. Consideration should also be given to other factors such as fan locations, length of piping runs, trash and dust collecting requirements, and seed and bale handling requirements. While it is not possible in this article to present a universal gin machinery plan that exactly fulfills everyone's specific needs, the plans presented in figures 4–2 and 4–3 are typical of current design practices for modern U.S. saw and roller gin plants.

Figure 4–2. A modern gin floor plan for a 12–16 bale/hr saw ginning system. *A*, Airline separator over a feed control; *B*, Dryers; *C*, Cylinder cleaners; *D*, Stick extractors; *E*, Hot-air push fans; *F*, Live overflow; *G*, Two saw gin stands; *H*, Overflow separator; *I*, Battery condenser; *J*, Bale press; *K*, Bale handling and wrapping equipment; *L*, Tandem saw-type lint cleaners; *M*, Press pump; *N*, Air compressor; *O*, Fan room; *P*, Trash cyclones.

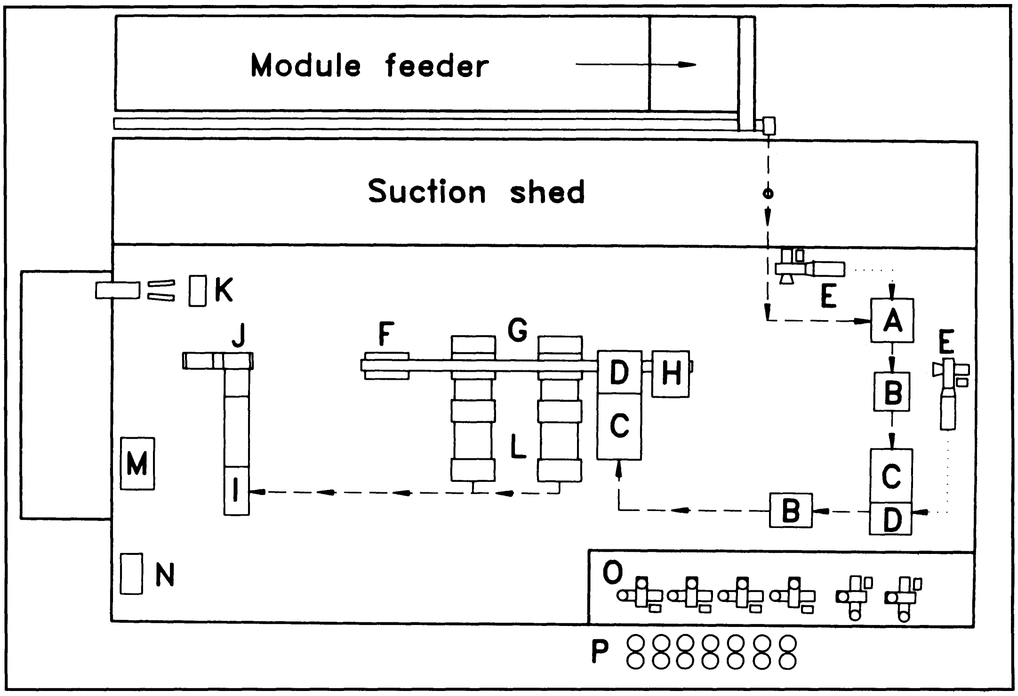
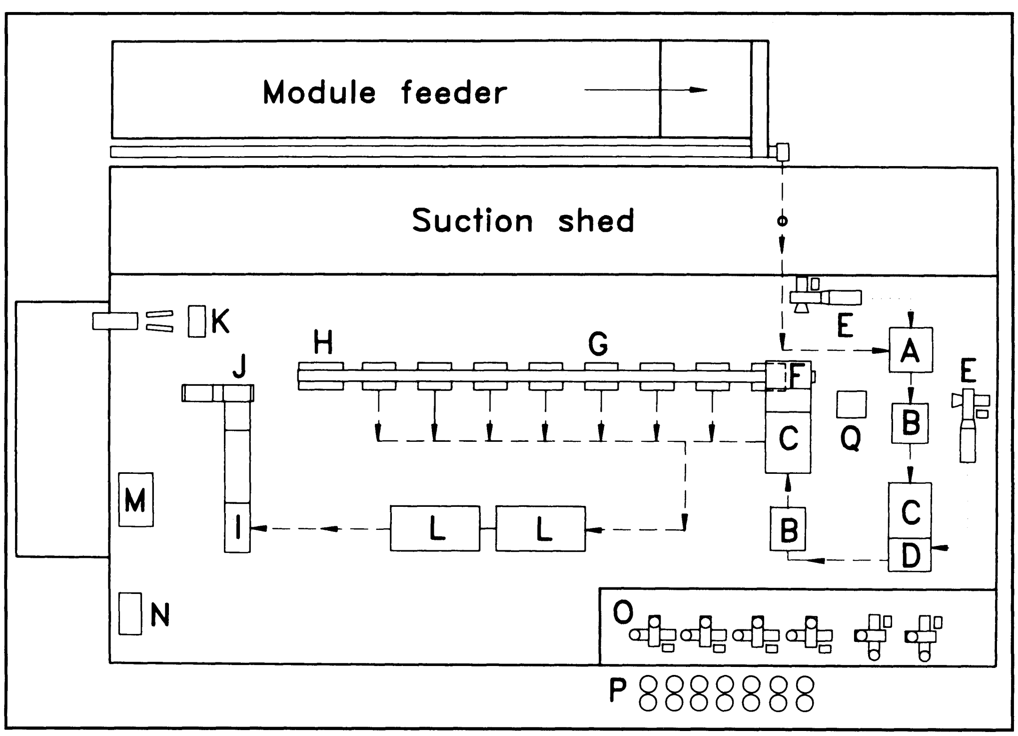


Figure 4–3. A modern gin floor plan for a 10 bale/hr roller gin system. *A*, Airline separator over a feed control; *B*, Dryers; *C*, Cylinder cleaners; *D*, Stick extractor; *E*, Hot-air push fans; *F*, Overflow separator; *G*, 8 roller gin stands; *H*, Live overflow; *I*, Battery condenser; *J*, Bale press; *K*, Bale handling equipment; *L*, Long-staple lint cleaners; *M*, Press pump; *N*, Air compressor; *O*, Fan room; *P*, Trash cyclones; *Q*, Seed reclaimer.



Overview of the Ginning Process

W.S. Anthony

Cotton possesses its highest fiber quality and best potential for spinning when it is on the stalk. Lint quality of the cotton in the bale depends on many factors, including variety, weather conditions, cultural and harvesting practices, moisture and trash content, and ginning processes.

The principal function of the cotton gin is to separate lint from seed, but the gin must also be equipped to remove from the cotton a large percentage of the foreign matter that would significantly reduce the value of the ginned lint. A ginner must have two objectives: (1) to produce lint of satisfactory quality for the grower's market and (2) to gin the cotton with minimum reduction in fiber spinning quality so that the cotton will meet the demands of its ultimate users—the spinner and the consumer. Accordingly, quality preservation during ginning requires the proper selection and operation of each machine that is included in a ginning system.

Mechanical handling and drying may modify the natural quality characteristics of cotton. At best, a ginner can only preserve the quality characteristics inherent in the cotton when it enters the gin. The following paragraphs briefly discuss the function of the major mechanical equipment and processes in the gin.

Green-Boll Trap

Cotton is transported from a trailer or module into a green-boll trap in the gin. The trap removes green bolls, rocks, and other heavy foreign matter. These heavy materials are removed early in the ginning system to prevent damage to machinery and to preserve fiber quality by removing immature cotton contained in unopened bolls.

Automatic Feed Control

The automatic feed control provides an even, well-dispersed flow of cotton so that the gin's cleaning and drying system will operate more efficiently. Cotton that is not well dispersed can travel through the drying system in clumps, and only the surface of that cotton will be dried.

Dryers

In the first stage of drying, heated air conveys the cotton through the shelves for 10–15 sec. The temperature of the conveying air is regulated to control the amount of drying. To prevent fiber damage, the temperature to which the cotton is exposed during normal operation should never exceed 350 °F. Temperatures above 300 °F can cause permanent physical changes in cotton fibers. Dryer-temperature sensors should be located as near as possible to the point where cotton and heated air mix together. If the temperature sensor is located near the exit of the tower dryer, the mixpoint temperature could actually be 100–200 °F higher than the temperature at the downstream sensor. The temperature drop downstream results from the cooling effect of evaporation and from heat loss through the walls of machinery and piping.

Cylinder Cleaners

The drying continues as the warm air moves the seed cotton to the cylinder cleaner, which consists of six or seven revolving spiked cylinders that rotate at 400–500 rpm. These cylinders scrub the cotton over a series of grid rods or screens, agitate the cotton, and allow fine foreign materials, such as leaves, trash, and dirt, to pass through the openings for disposal. Cylinder cleaners break up large wads and generally condition the cotton for additional cleaning and drying. Processing rates of about two bales per hour per foot of cylinder length are common.

Stick Machines

The stick machine removes larger foreign matter, such as burs and sticks, from the cotton. Stick machines use the centrifugal force created by saw cylinders rotating at 300–400 rpm to “sling off” foreign material while the fiber is held by the saw. The foreign matter that is slung off the reclaimer feeds into the trash-handling system. Processing rates of 1.5–2.0 bales/hr/ft of cylinder length are common.

Conveyor-Distributor

After going through another stage of drying and cylinder cleaning, cotton is distributed to each gin stand by the conveyor-distributor. It is important to keep the conveyor-distributor full so that the last gin stand will be supplied with cotton.

Extractor-Feeder

Located above the gin stand, the extractor-feeder meters seed cotton uniformly to the gin stand at controllable rates and cleans seed cotton as a secondary function. The moisture content of cotton fiber at the extractor-feeder apron is critical. The moisture must be low enough that foreign matter can be easily removed in the gin stand. However, the moisture must not be so low (below 5 percent) as to result in the breakage of individual fibers as they are separated from the seed. This breakage causes an appreciable reduction both in fiber length and lint turnout. From a quality standpoint, cotton with a higher content of short fibers produces excessive waste at the textile mill and is less desirable. Excessive breakage of fibers can be avoided by maintaining a moisture content of 6–7 percent at the extractor-feeder apron.

Gin Stand

Cotton enters the gin stand through a huller front. The saws grasp the cotton and draw it through widely spaced ribs known as huller ribs. The locks of cotton are drawn from the huller ribs into the bottom of the roll box. The actual ginning process—separation of lint and seed—takes place in the roll box of the gin stand.

The ginning action is caused by a set of saws rotating between ginning ribs. The saw teeth pass between the ribs at the ginning point. Here the leading edge of the teeth is approximately parallel to the rib, and the teeth pull the fibers from the seed, which are too large to pass between the ribs.

Gin stand adjustments should begin with those recommended by the manufacturer. While seed roll density can be adjusted by several methods, one method is to adjust the seed finger pressure to make the seeds stay in the roll for a longer period. This tends to reduce the overall ginning capacity of the stand because thorough cleaning of the seed takes more time. However, excessively loose adjustment of the seed fingers results in too much lint being left on the seed.

Ginning at rates above those recommended by the manufacturer can cause fiber quality reduction, seed damage, and chokeups. Gin stand saw speeds are also important. High speeds tend to increase the fiber damage done during ginning.

Lint Cleaners

It is very important for cotton to flow uniformly and be well dispersed, particularly as it leaves the gin stand. Cotton is conveyed from the gin stand through lint ducts to condensers and formed again into a batt. The batt is removed from the condenser drum and fed into the saw-type lint cleaner. The batt should be of uniform thickness and be evenly spread over the entire width of the lint cleaner; otherwise, poor cleaning and excessive fiber loss will result.

Inside the lint cleaner, cotton passes through the feed rollers and over the feed plate, which applies the fibers to the lint cleaner saw. The saw carries cotton under grid bars, which are aided by centrifugal force and remove immature seeds and foreign matter. It is important that the clearance between the saw tips and grid bars be properly set. The grid bars must be straight with a sharp leading edge to avoid reducing cleaning efficiency and increasing lint loss. Increasing the lint cleaner's feed rate above the manufacturer's recommended rate will decrease cleaning efficiency and increase loss of good fiber.

Lint cleaners can improve the grade of cotton by removing foreign matter. In some cases, lint cleaners may improve the color of a lightly spotted cotton by blending to produce a white grade. They may also improve the color grade of a spotted cotton to light spotted or perhaps white color grade.

All ginners must compromise between degree of cleaning and fiber damage. Fiber length can be damaged by excessive lint cleaning, especially when the cotton is too dry. Ginners should determine the number of lint cleaners that gives maximum bale value based on a compromise between increased grade, reduced staple length, and reduced turnout.

Bale Press

The cleaned cotton is compressed into bales, which must then be covered to protect them from contamination during transportation and storage. Three types of bales are produced: modified flat, compress universal density, and gin universal density. These bales are packaged at densities of 14 and 28 lb/ft^3 for the modified flat and universal density bales, respectively. In most gins cotton is packaged in a "double-box" press wherein the lint is initially compacted in one press box by a mechanical or hydraulic tramper; then the press box is rotated, and the lint is further compressed to about 20 or 40 lb/ft^3 by modified flat or gin universal density presses, respectively. Modified flat bales are recompressed to become compress universal density bales in a later operation to achieve optimum freight rates. In 1992, about 90 percent of the bales in the United States were gin universal density bales.

Bales should be packaged and tied only in material approved for storage by the Commodity Credit Corporation loan program.

Summary

A ginner must produce a quality of lint that brings the grower maximum value while meeting the demands of the spinner and consumer. Operating gin machinery in accord with the recommended speeds, adjustments, maintenance, and sequence while ginning the cotton at the optimum moisture level will produce the best possible end product.

Seed Cotton Unloading Systems

J.W. Laird, B.M. Norman, S. Stuller, and P. Bodovsky

Functions

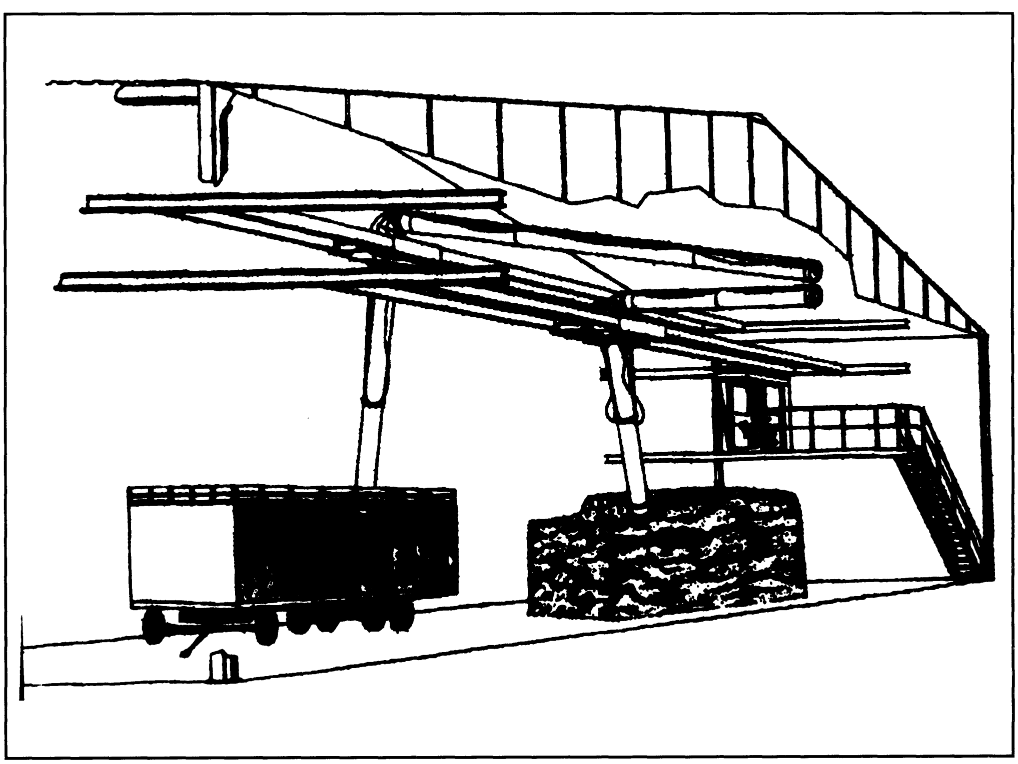
The essential requirements of seed cotton unloading systems are to remove seed cotton from the transport vehicle that delivers it to the gin site and to feed cotton into the gin at a constant and uniform rate. An auxiliary function is to remove rocks, metal, or other hazardous material and to remove wet green bolls and some sand and dirt. The functions of the unloading system vary somewhat with the harvest method and with the transport and storage method used between field and gin. The main storage methods used for harvested seed cotton in the U.S. cotton industry involve trailers or modules. There are two types of modern seed cotton unloading systems associated with trailer or module storage: (1) pneumatic suction through swinging telescopes that remove cotton directly from the trailer or module and (2) module disperser systems that break up the module mechanically and deposit the seed cotton onto a conveyor that delivers it to a fixed suction pickup point.

Telescope Suction Systems

Traditionally, cotton delivered to the gin was contained in trailers and transferred to the processing system through a pneumatic suction system. Pneumatic suction was included very early in the development of mechanical cotton handling systems. Through the years there have been improvements in materials and methods used in constructing pneumatic suction equipment. Suction telescopes were all manually operated until recently, when increased ginning capacity necessitated the use of power for their operation. Some gins now use electricity or hydraulics or both to swing, track, lift, and lower the telescope. In 1976 Stuller Engineering developed and manufactured the first successful remote-controlled hydraulic suction system. Power assist systems with control sensors that augment the operator's effort and fully automated systems controlled through joysticks manipulated by an operator in an elevated booth (fig. 5–1) are available.

The components of a remote-controlled suction system are illustrated in figure 5–2. The operating speed of the various components is adjustable at the hydraulic valve bank, which is usually located on the suction head or track frame. The manufacturer's instructions for adjustment and operation of a remote-controlled system should be closely followed. The operator is provided with a two-speed switch for the swing that pivots across trailers. The low speed should be used when the telescope is extended beyond half way and the high speed when it is retracted. Fast movement of the end of the telescope does not allow sufficient time for the airstream to break the cotton

Figure 5–1. A powered suction telescope system controlled by an operator in an enclosed elevated booth (courtesy of Continental Eagle Corporation)



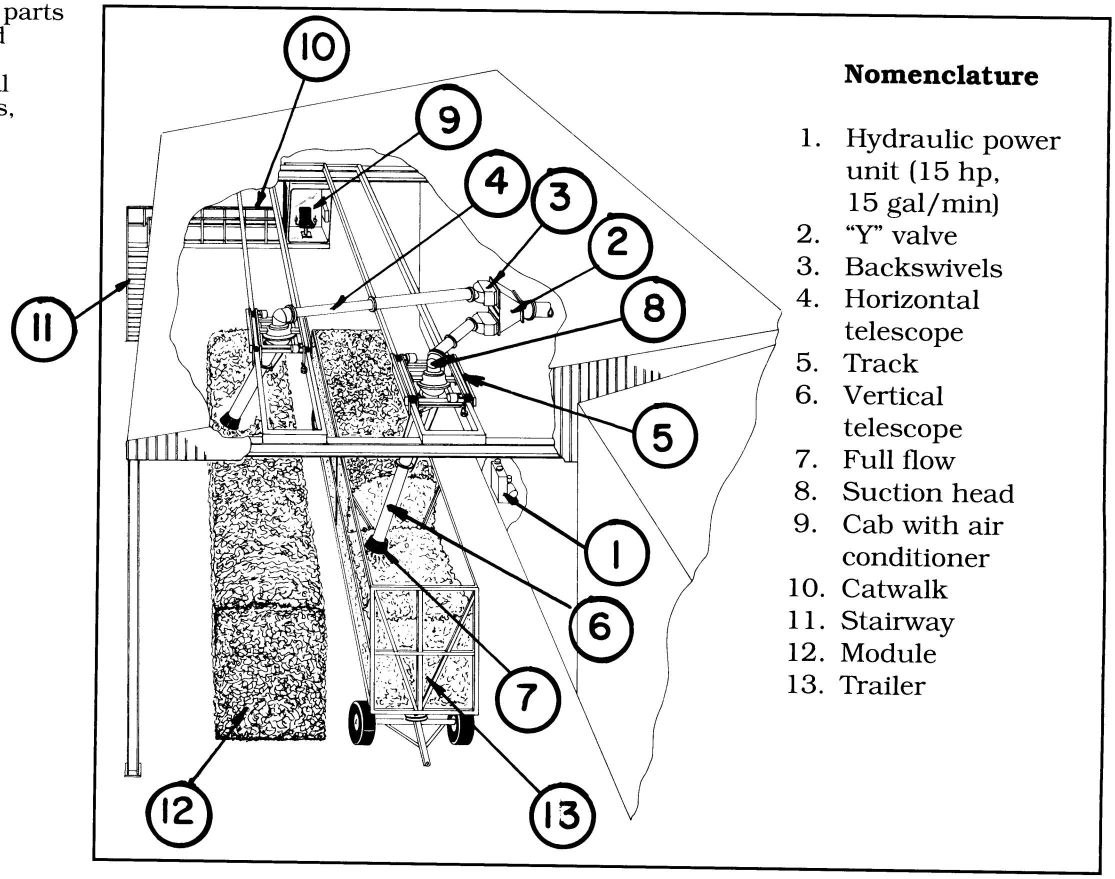


Figure 5–2. Working parts of a remote controlled suction telescope (courtesy of Industrial Business Consultants, Inc.)

loose from the load and suck it into the pipe. A flared tip on the suction telescope is helpful in directing the airflow into the opening without jamming it with large cotton wads.

Cotton Module Feeders

In the early 1970's technology was developed for packing harvested cotton on the turnrow into freestanding modules containing 18,000–22,000 lb of seed cotton. These modules could be mechanically handled as a single unit and dramatically changed the way cotton was stored, transported, and ginned. While the initial moduling system allowed the grower to reduce harvest time, it burdened the gins with the task of handling and feeding the tightly packed cotton from the module into the gin plant with a manual telescope suction system. Some gins installed automated heavy-duty telescopes, but these telescopes did not allow ginners to realize the full potential of cotton modules.

In 1975, a stationary module feeding mechanism was developed by Lambert Wilkes at Texas A & M University in cooperation with Cotton Incorporated. The machine uses rotating spiked cylinders to pick the tightly packed module apart and feed it to a conveyor for delivery to the gin. The first mobile module feeder was built by McClesky Gin in Seminole, TX, in 1975. In 1976 Continental Conveyor & Equipment Company patented the first commercial mobile module feeder and marketed it to the ginning industry. Subsequently, several manufacturers have begun building and marketing several types of mobile and stationary module feeding mechanisms.

The advantages of module feeding are as follows:

1. It increases ginning capacity by 10–25 percent by providing a consistent, uninterrupted flow of cotton to the gin plant.

2. It eliminates suction telescope labor.

3. It frees the module truck for long hauls by enabling continuous ginning of two to six modules.

4. It blends wet cotton in the module with dry cotton.

5. It extracts trash, thereby not only reducing the amount of trash entering the gin but also increasing fan and piping life.

Two types of module feeders are currently in use: the stationary head feeder (fig. 5–3) and the mobile head feeder (fig. 5–4). Both types employ a dispersing head with spiked rollers for breaking apart the module. The modules are transported to the stationary dispersing head on a series of beds; each bed is the length of a module and is constructed of flat wire-mesh belts or of chains similar to those of the module truck live bed. A minimum of 1-1/2 beds is required, but additional beds can be added to increase ginning time. The beds can be loaded directly from the module truck once the bed speed and the module truck bed speed are synchronized. After all of the beds are loaded with modules, the ginner selects a bed speed to feed cotton to the dispersing head at a constant rate. When the end bed is emptied, another module can be loaded onto the bed so that ginning is continuous. The modules must be butted end to end to prevent the last part of a module from falling apart as it

Figure 5–3. Stationary-head module feeder system followed by a sand cleaner delivering cotton into a suction pickup line (courtesy of Continental Eagle Corporation)

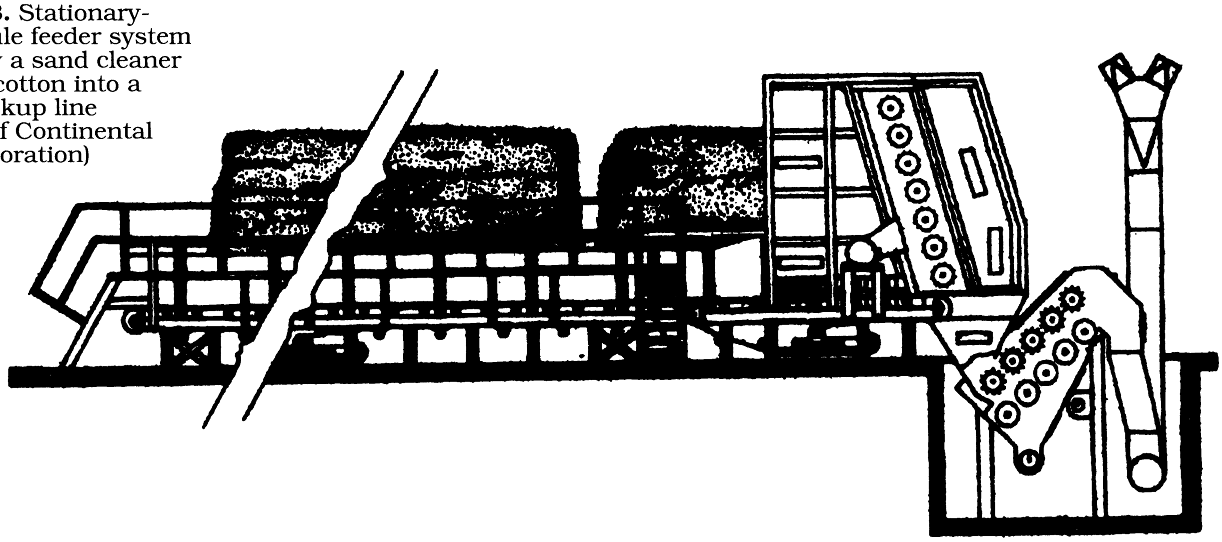
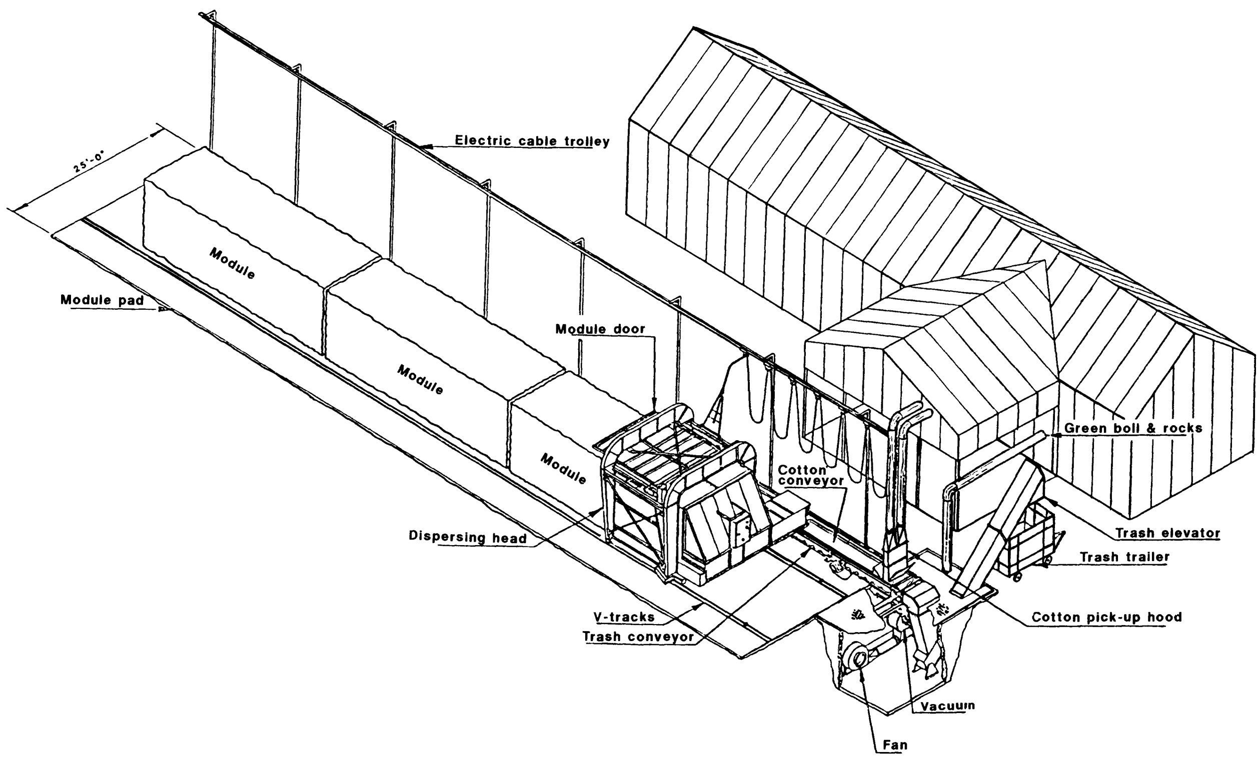


Figure 5–4. Typical layout for moving-head-type module feeder system. Pad length ranges from 100 feet for a two-module system to 230 feet for a six-module system (courtesy of Beltwide Industrial and Gin Supply Company, Inc.).



enters the dispersing head. The stationary dispersing head is equipped with a series of horizontal spiked cylinders that remove cotton from the face of the module and deposit the cotton onto a conveyor or into an air line for mechanical or pneumatic conveying to the gin.

The mobile head feeder is located on a cement pad 25 ft wide by a length equal to that of two to six modules. In heavy rainfall areas, a building should cover the entire pad to permit operation in bad weather. The mobile dispersing head is mounted on V-tracks that run the full length of the feeder pad and is powered by two motors: one high speed, the other slow and variable speed. The high-speed drive moves the dispersing head to bring it into contact with the modules, which are placed end to end on the pad. The slow variable-speed drive moves the dispersing head over and through the modules, unloading them in sequence. The slow variable-speed drive is used to regulate the cotton flow rate to the gin.

A belt conveyor is located along the full length of the feeder travel lane. The conveyor receives cotton from the dispersing head and conveys it to the end of the pad, where the cotton is picked up through a suction hood and transferred to the gin.

The mobile head feeder is equipped with a module containment door, which, when closed, keeps the cotton within the feeder and forces the module remnant into the dispersing cylinders.

A typical operating sequence for a mobile feeder is as follows:

1. The pad is loaded with modules from a truck or yard trailer.

2. Using the high-speed drive, the feeder operator moves the feeder to the module feed position.

3. The operator starts the feeder cylinders and belt conveyor and sets the controls to automatic.

4. When the ginner is ready for the cotton, the feeder travel is turned on manually and the travel speed set to provide the desired flow rate.

5. The feeder processes the entire module laydown, and at the end of the last module the operator closes the module containment door and returns the feeder to the reload position. As the feeder is being returned to this position, the next truck to be unloaded follows the feeder. As soon as the feeder reaches the reload position and the containment door is opened, the modules are unloaded from the truck. In some models that use a dual-head feeder, the pad is reloaded with modules from the opposite side of the feeder as the head nears the end of the pad. An experienced operator can dovetail the functions to ensure that there is no downtime in the ginning process during reloading.

6. To return to trailer ginning, the feeder operator switches the air valve back to telescope suction.

Feeder Options

Trash removers can be added to both types of feeders. On the stationary feeder a cylinder cleaner can be installed to receive the cotton from the feeder before transfer to the gin. On the moving head feeder, a cleaner screen can be placed under the twin cotton conveyors so that trash drops out as the cotton is conveyed to the side belt conveyor. The trash drops into screw conveyors that move it to the end of the pad, where the trash is either deposited in a trailer or pneumatically conveyed to a cyclone. Field checks have shown that the feeder trash extractor removes approximately 12 percent of the total trash content.

A hot-air box is available to provide hot air for the suction that picks up cotton from module feeders. This hot air provides additional drying for wet cotton. A pull-through burner is located near the feeder, and the heat from the burner is piped to a special hood where the cotton is picked up with the hot air. The hot air from the burner and the cotton are pulled into the gin by one of two methods. One method is to use the existing suction system piped to the hot box, and the other method is to bypass the existing suction system and the No. 1 dryer by piping the hot box discharge directly to the No. 1 cleaner and using the No. 1 pull fan for conveying air.

Feeder Requirements
The horsepower requirements for the components of the feeders are shown in the box on the right.

	hp
Stationary feeder:	
Dispersing head	25
Feeding bed	5
Each additional bed	5
Mobile feeder:	
Dispersing cylinders	25
High-speed drive	5
Feed rate drive	1
Screw conveyor	7.5
Door drive	1
Belt conveyor	7.5

Generally, if the existing suction telescope system has ample air for trailer suction, then the available air is sufficient for transferring cotton from the feeder to the gin as long as the feeder cotton pickup point is located next to the suction shed. To be sure that the air is sufficient, take air readings of the suction fan to determine airflow volume produced, and size the pipe to give a travel velocity of at least 5,000 ft/min.

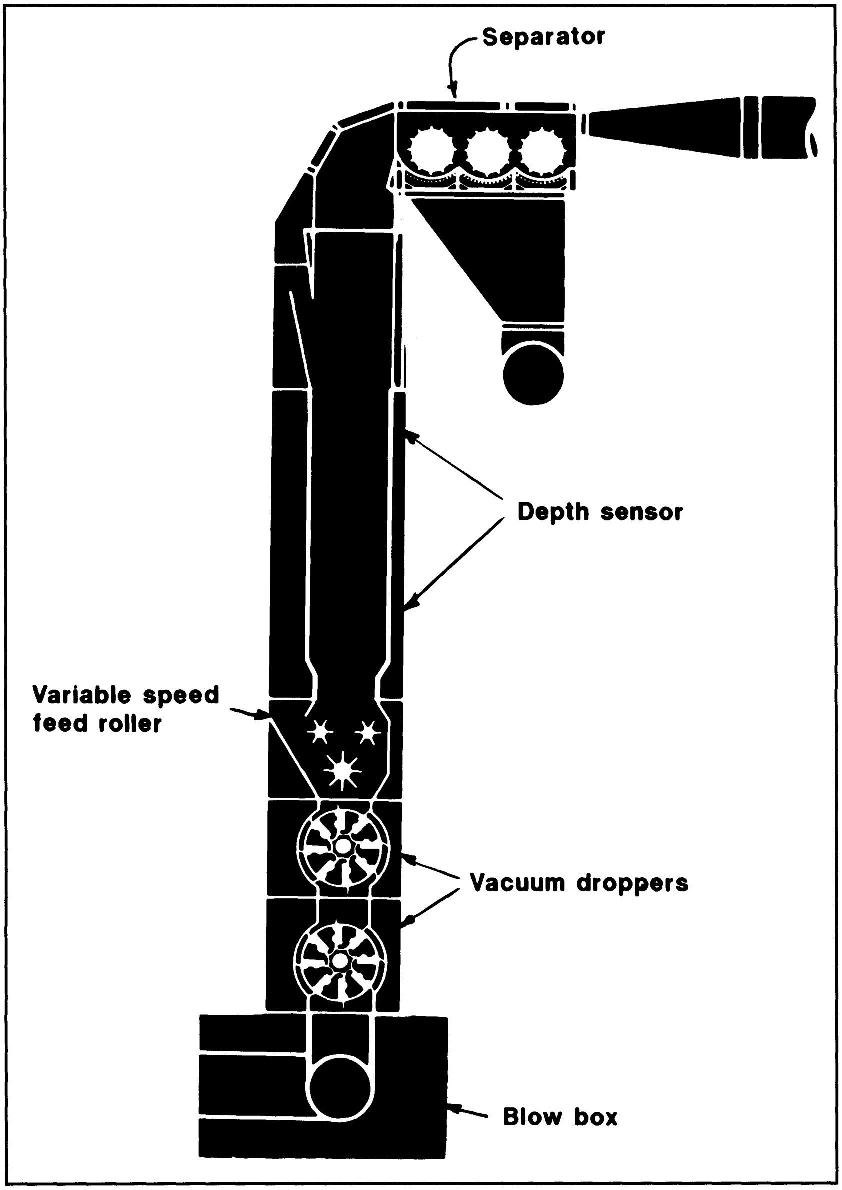
Feed Rate Control

The feed rate for telescope suction systems is automatically controlled by a surge bin (feed control hopper or steady flow hopper) (fig. 5–5). Sensors in the surge bin turn the suction off and on by opening and closing a valve in the suction line of the telescope. Output feed rate is controlled by regulating the speed of feed rollers in the bottom of the surge bin. A variable-speed drive on module dispersers may be interconnected with the surge bin sensors or can be used independently. Either system provides a remote variable-speed control that allows overall control of the unloading rate.

Unloading system capacity depends on the condition of the cotton and unloading system. Damp, trashy, and tightly packed cotton unloads slower and requires more horsepower than does clean, loose cotton. The suction fan has to provide sufficient vacuum pressure to overcome system resistance, to break the cotton loose and entrain it in the conveying air stream, and to compensate for leakage through piping and equipment. Velocity in the conveying pipes from the telescope to the unloading separator must be maintained at 5,000 ft/min for successful conveying. Velocity in the vertical suction telescope should be higher: 5,500–6,000 ft/min is typical. About 20 ft^3 of air/lb of cotton is required, with the higher volume required to handle damp, tightly packed cotton.

Typical sizes, unloading capacities, fans sizes, and power requirements for telescope suction unloading systems are shown in table 5–1. These data are applicable for clean, dry cotton. Capacity and power requirement depend on length of pipe, number and radius of elbows, type and condition of cotton,

Figure 5–5. Seed cotton feed control hopper and dual vacuum discharge separator ("Big J" system, courtesy of Continental Eagle Corporation)



number and type of auxiliary machines in the suction circuit, and how well the system is sealed against leakage all the way to the fan. Unloading capacity can be higher when the suction pickup is fed by a module disperser.

A simple, direct suction unloading system requires a fan capable of producing a minimum of about 20 inches of water static pressure at rated flow. Longer, higher capacity unloading systems with green-boll separators and air line cleaners or sand separators require much higher fan static pressures. Module dispersers relieve the load on the unloading fan by loosening the cotton and dispersing wads. However, this advantage is often lost because of the increased resistance associated with the additional pipe and elbows required for the installation of a module disperser. Suction unloading sys-

Table 5–1.
Typical pipe sizes, unloading capacities, fan sizes, and horsepower requirements for suction unloading and conveying systems handling machine-picked and machine-stripped seed cotton

Suction pipe diameter (inches)	Unloading capacity (bales/hr)[1] Machine picked	Machine stripped	Fan size	Motor (hp)
13	15	10	45	40
14	17	12	50	50
15	19	13	Series 45	60
16	22	15	Series 45	70
17	25	17	Series 50	75
18	28	19	55	100
19	32	22	60	125
20	35	24	60	125

[1]Based on 1,500 lb of machine-picked seed cotton and 2,200 lb of machine-stripped seed cotton per bale, velocity in the telescope of 6,000 ft/min, and 15 ft^3 of air/lb of cotton.

tems should be designed to be as short and direct as possible and to have a minimum of auxiliary equipment. This can greatly improve system capacity and reduce horsepower requirement.

Seed cotton that has been opened and entrained in an air line settles at a density of 2–3 lb/ft^3 when it is dropped into a container such as the surge bin. Cotton compresses from its own weight, and density increases to 4–6 lb/ft^3 at a 6- to 8-ft depth. The surge bin normally needs to contain about a 30-sec supply of cotton to avoid running out of cotton during momentary lapses in feeding from the unloading system. Under most conditions lapses can be avoided by providing surge bin volume of about 5–8 cubic feet for each bale per hour ginned. The rollers in the bottom of the feed control hopper that feed cotton to the gin can choke if the depth sensors are adjusted to allow a depth of more than about 6–8 ft of cotton to accumulate. Feed roller and vacuum dropper speed can be adjusted over a wide range, but the normal maximum feed rate is about 4–5 bales/hr/ft of surge bin width.

Unloading system repair and maintenance should be done with careful consideration of basic safety principles (see section 11). Consult with the manufacturer or personnel experienced in unloading system design before making modifications.

Foreign Objects in Cotton

Periodically, machine-stripped cotton contains many green, immature bolls that cause ginning problems, such as clogging of the sawteeth, failure of the seed roll to turn, accumulation of sticky material on the inner surface of the roll boxes and on the saws and moting surfaces of the gin stands, and occasional clogging of other machines (Wakelyn et al. 1972). Many of the green bolls are broken open by the cleaning machines, and their contents add moisture to the adjacent cotton. Also, moisture is transferred from other wet plant materials to dry cotton, causing ginning problems. Cotton and cottonseed, especially when immature, contain small amounts of substances that become sticky when wet and that can be responsible for the gumming of gin machinery. These substances appear mostly in unopened or early-season cotton exposed to limited weathering, particularly in dry climates. Apparently, the substances change with maturation of the cotton or are degraded by the effects of weathering and are therefore not troublesome late in the harvest season.

Spindle pickers and machine strippers will pick up rocks, clods, metal scrap, roots, and other heavy objects in the field. These contaminants must be removed before the cotton reaches the gin's processing machines, or they will damage the machines and cause chokes or fires.

Effective green-boll removers mounted directly on stripper harvesters reduce the number of green bolls, rocks, and other heavy objects in the cotton (Kirk and Hudspeth 1964). The overhead basket stripper harvester is helpful because, rather than concentrating the green bolls in one spot in a trailer or module, it tends to spread them out, producing a uniform load on the green-boll separator in the gin. Uniform spreading also helps minimize moisture transfer and spontaneous heating problems.

Green bolls should be removed as close to the harvester as possible. Ginning problems start to occur at a green-boll content of about 10 percent. Scattering the green bolls improves the efficiency of green-boll removers and prevents hot spots as long as the green-boll concentration in all parts of the load is kept below about 5–6 percent. Long-term seed cotton storage helps by allowing sufficient time for wet, green bolls to dry. Building modules directly on the ground has also made rock, clod, and heavy object removal by green-boll traps more important.

Various devices are used in cotton gin unloading systems to remove green bolls, rocks, and other heavy objects from cotton. Some devices use a suitable air velocity gradient to separate the dense materials from the lighter, less dense open bolls (Laird and Baker 1973). In most pipes conveying seed cotton in the gin, the air velocity is high enough to transport the heavy materials. Separation can be effected in a chamber where the air velocity is reduced to such a point that heavy materials settle out while the open bolls stay in the airstream.

Another means of separation used by some devices is centrifugal force. Since the centrifugal force that acts on an object is proportional to its weight, the heavy materials may be separated by moving the mixture of cotton and foreign materials through a duct that abruptly changes direction. As the duct changes direction, open bolls follow the path of the air more closely because the air-drag force on them is greater than the centrifugal force on them. The dense materials, however, tend to continue in the original direction of travel and are expelled from the airstream into a suitable collection chamber.

Some rock and green-boll traps employ a combination of settling chamber and centrifugal force (fig. 5–6). The hopper type of rock and green-boll trap has been widely adopted by the industry. Some models use a counter-weighted trapdoor and a short accumulating pipe in place of the vacuum dropper. The trapdoor is held closed by suction while cotton is being unloaded; when the suction valve cycles off, the weight of the trapped materials causes the trapdoor to open and dump the materials. For successful operation, the manufacturer's recommendations on air velocity and baffle adjustment should be closely followed. The trap should be inspected frequently to see that the baffle and reclaiming airspeed are properly adjusted for the type of cotton being processed.

The reclaiming airstream is an undesirable feature because it reduces suction unloading capacity and increases horsepower requirements, but the airstream is necessary to prevent loss of open cotton. Keep the deflector adjusted as high as possible and the reclaiming air at the minimum consistent with acceptable rock and green-boll removal. The power requirement for the reclaiming airstream under typical conditions may be as much as 15 hp.

Another type of heavy-object trap (fig. 5–7) is widely used in the belt-feed unloading systems of the module disperser. In this trap, a thin layer of the harvested cotton is deposited on a conveyor belt traveling at about 500–700 ft/min. A suction pickup hood at the end of the belt lifts the open cotton while the heavier green bolls, clods, rocks, and metal remain on the belt and are discharged over the end. This type of trap has been shown to remove about 90 percent of green bolls, with a lint loss of less than one-fourth pound per bale when used on cotton containing up to 11 percent green bolls (Taylor 1964).

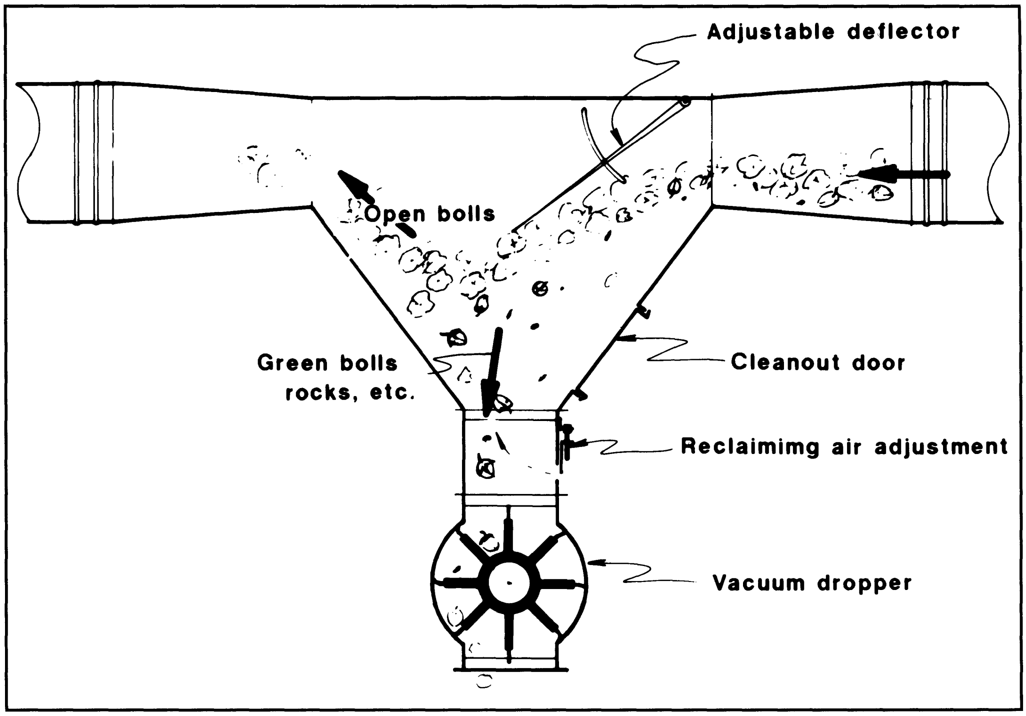


Figure 5–6. Hopper-type rock and green-boll trap

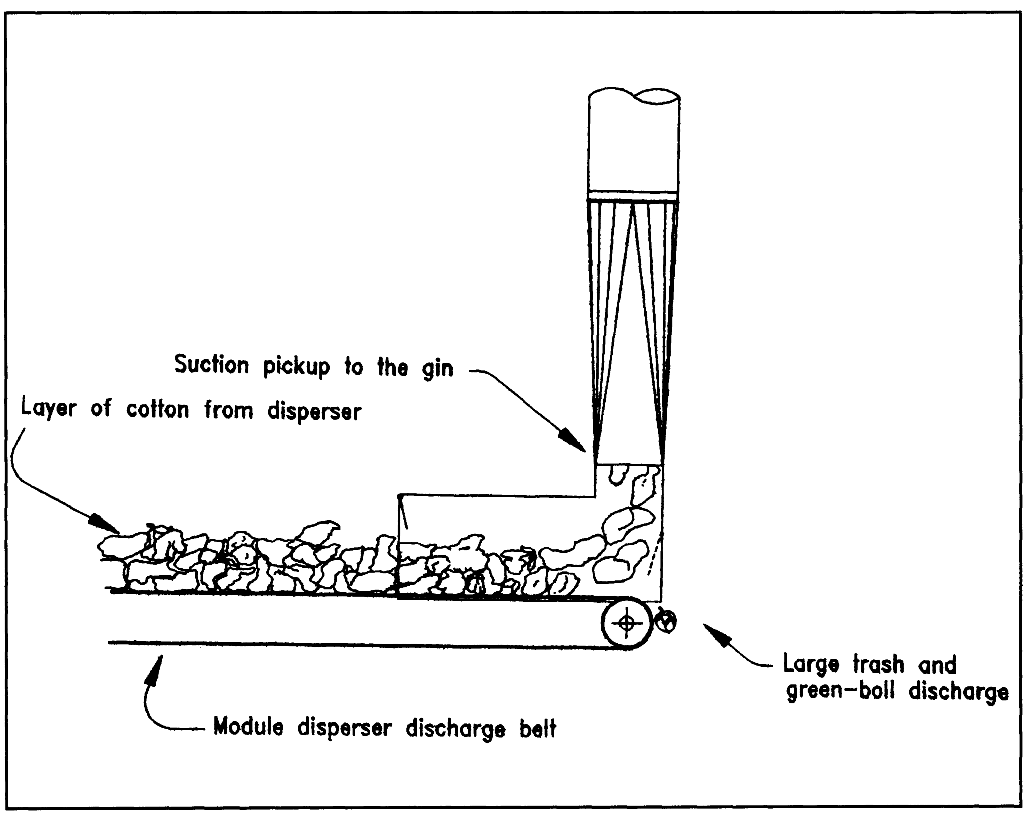


Figure 5–7. Conveyor-belt suction-duct-type green-boll separator

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Moisture Control

S.E. Hughs, G.J. Mangialardi, Jr., and S.G. Jackson

The moisture content of seed cotton is very important in the ginning process. Seed cotton having too high a moisture content will not clean or gin properly and will not easily separate into single locks but will form wads that may choke and damage gin machinery or entirely stop the ginning process. Cotton with too low a moisture content may stick to metal surfaces as a result of static electricity generated on the fibers and cause machinery to choke and stop. Fiber dried to very low moisture content becomes brittle and will be damaged by the mechanical process required for cleaning and ginning. When pressing and baling such low-moisture cotton, it is often difficult to achieve the desired bale weight and density without adding moisture. Drying cotton at high temperatures may damage the cotton fiber. Early drying recommendations were that drying temperatures should not exceed 200 °F (Bennett 1932). There is an optimum fiber moisture content for each process in the gin. The effort required to control moisture will pay dividends in gin operating efficiency and market value of the baled cotton.

Both constituents of seed cotton—fiber and seed—are hygroscopic but at different levels (fig. 5–8). Dry cotton placed in damp air will gain moisture, and wet cotton placed in dry air will lose moisture. For every combination of ambient air temperature and relative humidity, there are corresponding equilibrium moisture contents for the seed cotton, fiber, and seed. For example, if seed cotton is placed in air of 50-percent relative humidity and 70 °F, the fibers will tend to reach a moisture content (wet basis) of approximately 6 percent; the seed will tend to reach a moisture content of about 9 percent; and the composite mass will approach a moisture content of 8 percent. The equilibrium moisture content at a given relative humidity is also a function of the temperature and barometric pressure.

Moisture occurs not only in fibers and seed (hygroscopic moisture) but also sometimes on their exterior surfaces (surface moisture). The ratio of hygro-

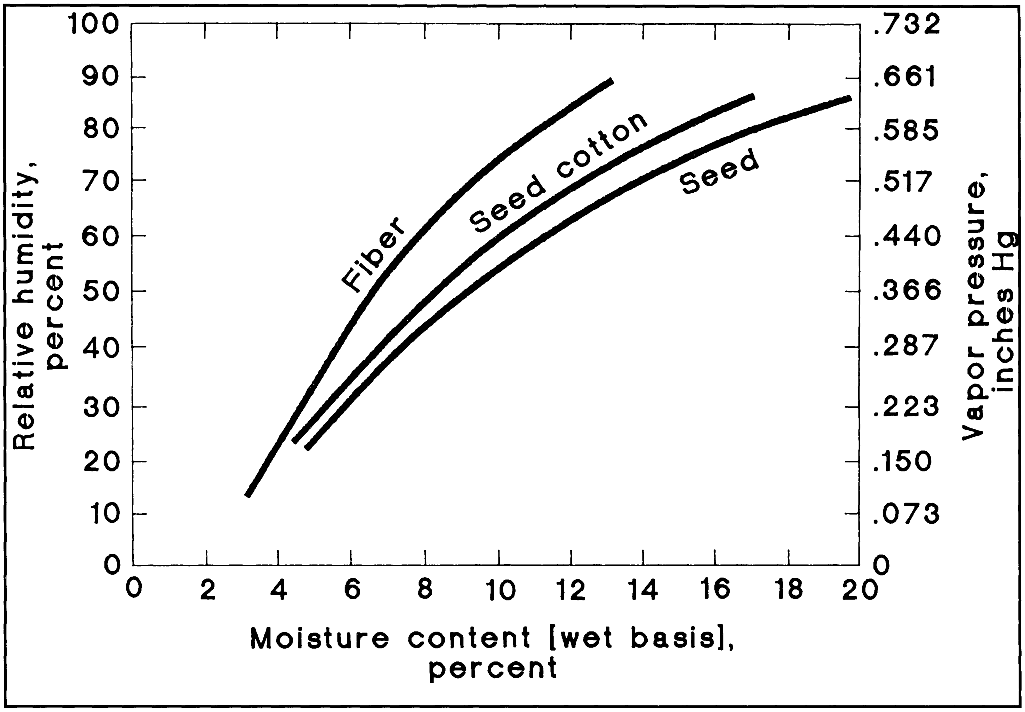


Figure 5–8. Equilibrium moisture contents of cotton fiber, seed cotton, and seed at different relative humidities at about 70 °F and 30 inches barometric pressure

scopic moisture to surface moisture varies considerably unless the cotton has been stored for some time in a stable atmosphere of constant relative humidity. The moisture contents (both hygroscopic and surface) of the fiber, seed, and trash of the seed cotton are influenced by weather, method of harvest, and time of storage between harvesting and ginning. Seed cotton that is damp or wet from rain or dew may have excessive surface moisture, whereas seed cotton exposed to moist air will have a high hygroscopic moisture content.

The effects of atmospheric conditions, particularly relative humidity, must be considered when harvesting seed cotton. As discussed earlier, ambient conditions at the time of harvest influence the moisture content of the harvested seed cotton. The effect of relative humidity on cotton moisture is relatively simple, useful, and easily understood for ambient conditions but is less useful or meaningful as air is heated in a gin drying system. As air is heated above the boiling point of water, the term "relative humidity" is no longer appropriate and must be replaced by "vapor pressure gradient" to define water movement in drying. Therefore, the discussion of cotton drying should be based on whether ambient or heated air is used for drying.

Drying Theory

The moisture in and on the cotton exerts vapor pressure that is a direct function of temperature. If the water vapor pressure in the surrounding air is less than the vapor pressure of the moisture in the cotton, drying will occur. Conversely, if the water vapor pressure in the surrounding air is greater than the vapor pressure of the moisture in the cotton, wetting will occur.

Although the main factor that determines the rate of drying is the vapor pressure gradient, other factors include: (1) temperature of the drying air, (2) pounds of drying air applied per pound of cotton, (3) openness of the cotton being dried, (4) exposure time, (5) relative velocity of the drying air to the cotton, and (6) moisture content of the cotton entering the dryer. Openness, exposure time, and velocity influence how efficiently the drying system uses the potential of the drying air.

Cotton can be dried at gins by using either ambient or heated air. When ambient air is used, the relative humidity (and consequently the vapor pressure of the air) must be equal to or less than that necessary to achieve the desired equilibrium moisture content of the cotton fiber (fig. 5–8). For example, to dry cotton fiber to a moisture content of 7 percent, the relative humidity of the air must be 55 percent or less (approximately 0.4 inches of mercury (Hg) vapor pressure).

Most of the active drying in cotton gins is done with heated air. As the air and seed cotton move through a dryer, the air temperature will drop because (1) heat is lost, (2) heat is used to increase the temperature of the cotton, and (3) moisture is vaporized from the cotton. Fiber temperature will increase until it is approximately the same as that of the surrounding air. Heat is normally transferred from the drying air to moisture in the fiber to raise the vapor pressure of the fiber above that of the air, causing the fiber moisture to vaporize. Heat used to drive each unit of moisture out of the fiber must be replaced to maintain the fiber at the same temperature. If heat is not added, the cooling effect of moisture evaporation will eventually stop the drying process. Airflow through the entire cotton mass is necessary to remove the liberated moisture and replace the heat losses from evaporation. This requirement explains the great importance of turbulence in some types of seed cotton dryers.

In a flow drying process, the fastest drying occurs at the beginning. The air is much hotter than the cotton and heats it quickly, raising the vapor pressure of the moisture in the cotton. The difference in vapor pressures is great because of the low moisture content of the heated air. As the process continues, the falling air temperature and rising cotton temperature slow the rate of heat transfer to the cotton. The reduced heat transfer rate, the reduced cotton moisture, and the increased air moisture content reduce the vapor pressure difference and slow the drying rate. As the moisture content of the cotton falls, the remaining moisture is that which is more closely bound to the cellulose, and the heat required to drive out each pound of moisture increases dramatically.

Most of the moisture removed during the short drying time in commercial gin dryers comes from the fibers rather than from the seed and trash. The seed constitute about 60 percent of the weight of spindle-harvested seed cotton. Moisture results based on oven drying of seed cotton do not necessarily indicate the ginning condition of the fibers. The moisture content of the seed is considerably less important from a ginning standpoint than the moisture content of the fibers, unless the seeds are so wet that they are soft or mushy. For satisfactory ginning, seed moisture content should not exceed 12 percent.

Effect of Drying on Fiber Quality

Proper drying of damp cotton benefits the producer, ginner, and spinner in several ways. Dryers condition the seed cotton for smoother and more continuous operation of the gin plant by removing excess moisture and by fluffing the partly opened locks. Seed cotton cleaning efficiency increases with increased gin drying (Cocke and Garner 1972). However, excessive drying can cause quality problems.

“Overdrying” is a vague and misused term. Cotton fiber dried to a low moisture level is not harmed if the drying is done at low temperature. Cotton fibers are often dried to about 4 or 5 percent moisture while still in the field. Overdrying damage comes from two sources: getting fibers too hot, and processing cotton through mechanical cleaners, gin stands, and saw-type lint cleaners while it is too dry and brittle.

Cotton should be dried at the lowest temperature that will allow satisfactory gin operation. Laboratory tests have shown that fibers will scorch at 450–500 °F, ignite at 450 °F, and flash at 550–600 °F (U.S. Department of Agriculture 1964). In no case should the temperature in any portion of the drying system exceed 350 °F (U.S. Department of Agriculture 1977).

The strength and short-fiber content of the cotton fiber are affected by its moisture content. Cotton fiber at 15 percent moisture content is approximately 1.7 times stronger than cotton fiber at 4 percent moisture (Moore and Griffin 1964). Cotton fiber that has been dried to excessively low moisture levels becomes weak and brittle, making it more likely to be broken during processing. If cotton fiber is dried from 5 percent to 3 percent moisture content, passing the cotton though two lint cleaners can increase its short fiber content by as much as 1.4 times. Likewise, length measurements such as staple or upper-quartile length decrease as fiber moisture decreases (Mangialardi and Griffin 1966).

Drying Practice

Drying systems across the Cotton Belt include reel-type, tower, tower hybrid, and towerless systems. Modern drying systems can seriously overdry cotton and must be used properly to avoid reducing cotton quality. Longer term drying at low temperatures is much less harmful than rapid drying at high temperatures. This means that two-stage drying at relatively low temperatures is preferable to single-stage drying at higher temperatures.

The air velocities and volumes necessary for proper operation of seed cotton dryers vary considerably, depending on the type of dryer and the rate of ginning. Air volumes used vary from 20 ft^3/lb of seed cotton in tower drying systems to 40–50 ft^3/lb in towerless systems. In the tower type, the air velocity must be sufficient to keep the cotton moving 4,000–5,000 ft/min in the piping and 1,500–2,000 ft/min in the dryers.

The cotton handling capacity of tower dryers may range from 8–30 bales/hr, depending upon dryer width, dryer shelf spacing, condition of the cotton, and quantity of air moving through the system.

Spindle-harvested cotton contains less waste and processes faster through tower dryers than stripped cotton. Rain-wet cotton and other relatively dense cottons must be handled with care to prevent temporary overloading and choking of the conveying system. The most critical locations in the drying system are in the pipe immediately below the bulk feed dropper and in the first few shelves at the top and bottom of the tower. On these shelves the air changes velocity suddenly as it moves from the conveying pipe into and out of the dryer.

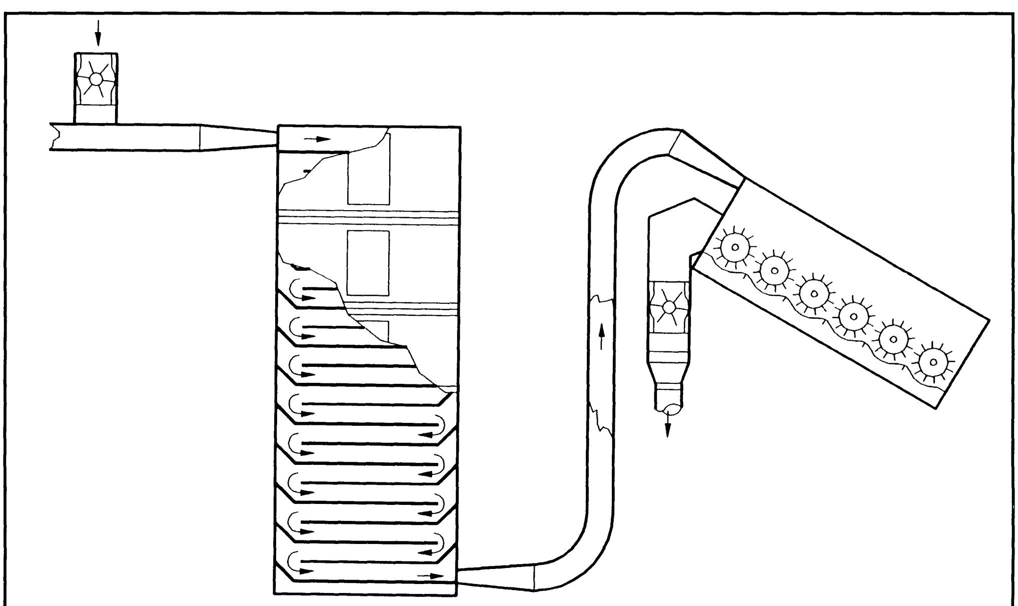
In pneumatic conveying systems the cotton and drying air move at different speeds. Damp, heavy, dense cottons move much slower than the air. As the cotton is opened and fluffed by moisture removal and mechanical action, it is more easily airborne, and its final velocity more nearly approaches that of the conveying air. Cotton is normally retained in a tower dryer 7–10 sec.

The typical gin drying system consists of a heater, one or more fans, piping, tower dryer, and seed cotton cleaner, which serves the dual purpose of separating the warm, moist air from the cotton and cleaning the cotton (fig. 5–9). There are wide variations in the layout of ginneries, so air requirements and drying exposure periods may be expected to differ from gin to gin.

The location of temperature control sensors is important. Many bales have been overdryed even though the sensing devices had indicated a safe drying-air temperature. When a temperature sensor is located well into the drying system—near the bottom of the dryer, for example—the temperature at the air-cotton mixpoint is considerably higher than that indicated by the sensor.

An additional factor to be considered is the effect of heat stored in the metal shelves of the tower dryer. When the temperature sensor is near the bottom of the dryer, the stored heat usually causes unstable operation of the auto-

Figure 5–9. Typical gin drying system. A fan and burner deliver heated air to the air-cotton pickup point, and a second fan is usually used to aid in conveying cotton through the system.



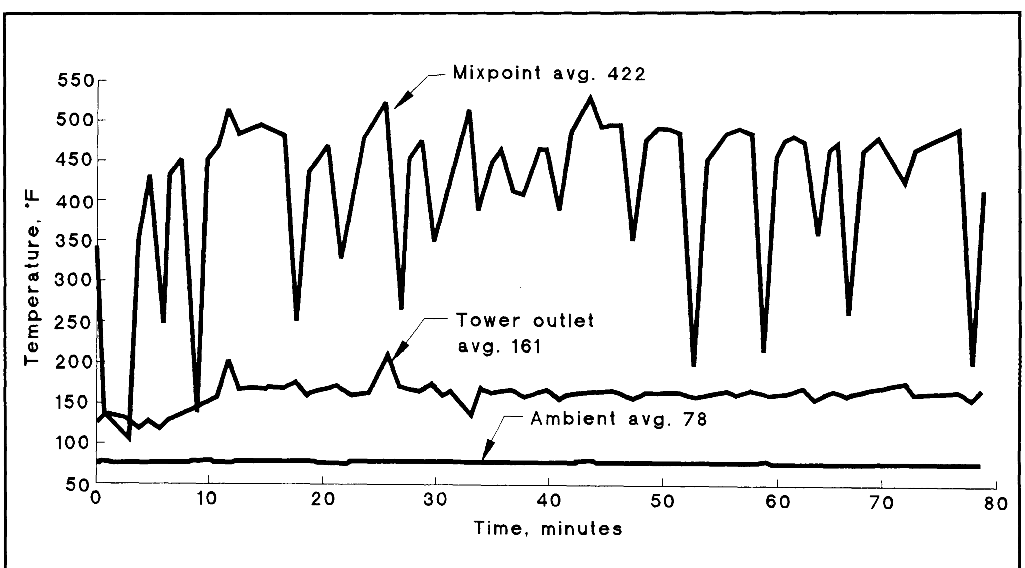
matic control even when a high-quality modulating controller is used. The control may therefore turn the tower dryer on and off every several minutes. This on-off cycling, however, may go unnoticed.

Figure 5–10 shows typical temperature variations of a first-stage tower drying system with the temperature controller sensor located two-thirds of the way down the tower. When the temperature controller was set at 180 °F, mixpoint temperatures averaged 422 °F and momentarily rose as high as 525 °F. The temperature control sensor should be located close enough to the mixpoint to respond quickly to changes in burner output. For rapid response the sensor should be installed where the air velocity is high but not where the sensor will be buffeted by the seed cotton. If the sensor is touched by wet or frozen cotton, the burner may react violently.

At first thought, placing the sensor in the hot-air line ahead of the mixpoint may seem a practical way to prevent scorching the cotton. If this is done, however, the controller's response to the amount and wetness of the cotton will be lost. The burner will run at the same high output all the time and thus damage the vacuum feeder flashings. Also, if only a small amount of cotton is fed, it will be seriously overdryed or scorched. It is preferable to use dual sensors, which will prevent scorching and excessive damage to cotton. The primary control sensor should be located downstream of the mixpoint, and a high-limit temperature switch (set for 350 °F) should be located ahead of the mixpoint. A recommended practice that should work in any tower drying system would be to locate the control sensor at the top of the dryer and to place a high-temperature burner cutoff switch (or at least a warning device) at the mixpoint.

The pace of modern ginning is too rapid for ginners to examine each load of cotton and adjust the drying system. Automatic dryer controls are necessary to reduce the variability of moisture content of the finished bales. Automatic

Figure 5–10. Tower dryer temperature versus time (temperature sensor is located at the bottom of the dryer)



controls can provide considerable energy savings by adjusting the heater fuel consumption to the amount actually needed to remove excess moisture from the cotton and by lowering the burner flames when no cotton is in the drying system.

Studies have shown the value of insulating drying systems to reduce heat losses (Childers 1978, Griffin 1979). Insulating materials tested ranged from 1-inch-thick fiberglass to 3-inch- thick thermal insulating wool. Mixpoint temperatures tested ranged from 160 to 350 °F, and fuel savings ranged from 21 to 28 percent. The higher the mixpoint temperature, the lower the fuel savings from a given insulation. This relation indicates that more insulation is needed for higher temperatures. Although fuel and insulation costs vary from area to area, dryer insulation could pay for itself after as few as 10,000 bales if fuel costs are reduced by 25 percent.

Another study showed that significant energy savings (about 15 percent) could be obtained by locating heating system air intakes near the roof level to recover some heat loss from drying systems and motor cooling (Laird and Baker 1985).

Seed cotton moisture (percent)		
Wagon	Feeder apron	Lint slide
15.4	13.2	7.2
13.8	11.0	6.4
12.2	9.4	5.2
11.5	9.6	5.5
10.4	8.8	5.7
9.8	8.0	4.9
9.3	7.9	4.0
8.2	6.9	3.6
6.9	6.2	4.1
6.8	5.3	3.4
6.4	5.6	3.7
5.1	4.2	3.2

The box on the left shows moisture contents (wet basis) of cotton that received identical seed cotton drying and that was passed through an 18-shelf tower dryer with a constant mixpoint drying temperature of 250 °F.

Initial seed cotton moisture (measured on the wagon) had a range of 10 percent moisture, whereas the dried lint (measured on the lint slide) had only a 4-percent range over the test. As the moisture content of the seed cotton on the wagon decreased, the amount of drying decreased.

Towerless Drying Systems

Towerless drying systems fall into three broad categories:

1. Those in which the tower dryers have been removed and replaced with pipe. Usually, the pipe sizes and airflows are increased in the first stage for higher air/cotton ratios. The push fans are removed, leaving only the pull fan. A single burner is usually shared by first and second stages.

2. Those similar to number one above but having an added first-stage dryer that can handle a high air volume with low pressure drop.

3. Those similar to number one but using push-pull fans and having special crossflow blow boxes with jets giving very high air velocities at both first- and second-stage mixpoints.

Towerless drying systems have been designed on the principle that drying is fastest whenever there is a big difference in the velocities of the air and seed cotton, such as the difference that occurs at the blow box pickup area or hot-air-cleaner separation area.

Fuels and Burners

The amount of fuel used by gin drying systems may be estimated in several ways. The simplest method is to relate fuel purchases to bales ginned, making allowance for fuel not used by the cotton dryers. When the rate of the air moving through the drying system is known (see "Pneumatic and Mechanical Handling Systems" in section 6 to determine the rate), figure 5–11 can be used to determine the Btu/hr needed to heat the airstream. Figure 5–11 can also be used as a means of checking the maximum output of heaters already

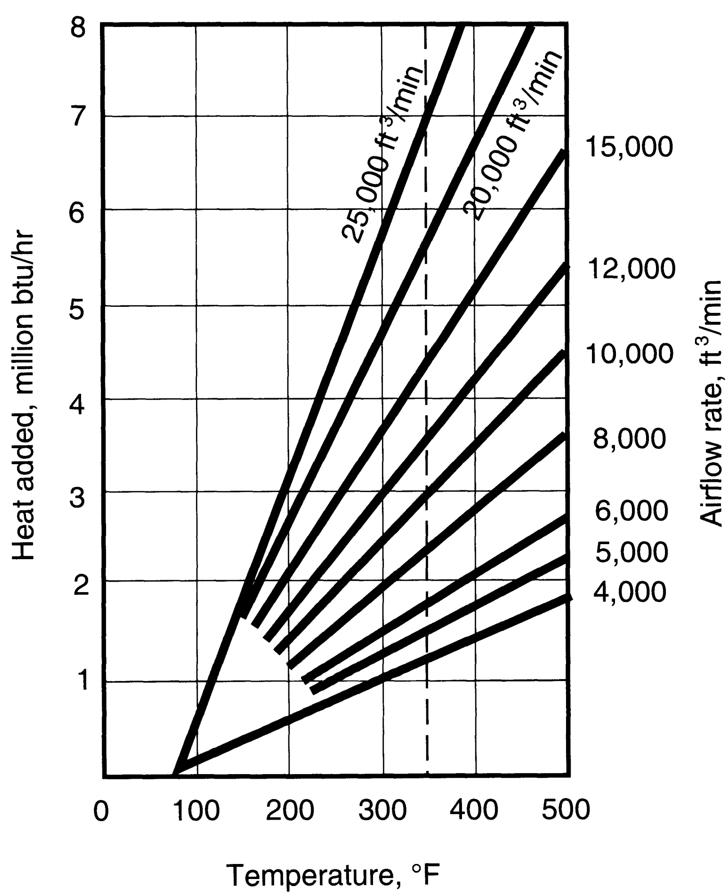


Figure 5–11. Heat-to-temperature relationships for air moving through a gin drying system from an initial temperature of 70 °F. Drying temperature should not exceed 350 °F.

installed by measuring the airstream temperatures ahead of and after each heater. For example, if the drying system is pulling 8,000 ft^3 of air/min and its temperature after the heater is 300 °F, then the heat being supplied is about 2 million Btu/hr. The values of figure 5–11 are based on the following equation:

$$\text{Btu/hr} = 1.08\ (\text{rate of air movement, ft}^3/\text{min})(T_2 - T_1),$$

where

T_1 = ambient air temperature (°F) and
T_2 = air temperature after the burner (°F).

The typical source of heat for drying cotton is a burner flame in the stream of drying air. Since the products of combustion and any unburned fuel will be mixed with the cotton, it is important that air heaters be selected for safe operation of the burner (where gaseous fuels are used) and for efficient combustion. Efficient combustion allows more drying with less fuel and does not produce smoky flames, which discolor the cotton. Another important selection criterion is whether the burner's maximum output will be adequate. The ratio of fuel flow rate at maximum burner output to the fuel flow rate that provides the lowest dependable flame is referred to as the "turndown ratio." This ratio is highly important in drying cotton. If the burner will not turn down to a low flame, the result will be overdryed cotton and wasted fuel. A good drying burner will have a guaranteed turndown ratio of at least 15, but the ratio can be as high as 35-to-1, depending on the manufacturer.

Fuel	Heat content, LHV	
Natural gas	970	Btu/ft^3
Commercial propane (LP)	91,600	Btu/gal

Two fuels, natural gas and liquefied propane (LP), are commonly used for drying cotton. The box on the left gives for the nominal heat contents (or lower heating values, LHV) of fuels commonly used in gin drying systems.

Assuming a combustion efficiency of 95 percent, the quantity of fuel required to yield 3 million Btu is about 3,500 ft^3 of natural gas or about 37.6 gal of commercial propane.

A sampling of 230 Midsouth cotton gins in 1988 showed that an average of about 248 ft^3 of natural gas or 2.3 gal of LP gas was required to dry a bale of cotton during the unusually dry 1987 harvest season (Anthony 1988). A normal drying season would likely require about 300 ft^3 of natural gas per bale or 3.3 gal of LP based on the heat contents shown above.

Moisture Restoration

Much of the U.S. cotton crop is harvested during low-humidity periods and can arrive at the ginnery with fiber moisture of 4–5 percent. Seed cotton cleaning is most effective at a low (5 percent) fiber moisture content (Hughs 1985), but lint and seed separation is less damaging to fibers that are somewhat higher in moisture content (6–7 percent). Since fiber breakage rate during ginning is inversely proportional to fiber moisture content at the gin stand and lint cleaners, the number of fibers that break may be minimized by conducting the fiber/seed separation and lint cleaning processes at as high a moisture level as practicable (Leonard et al. 1970). The average fiber length of excessively dry cotton may be maintained by adding moisture before fiber/seed separation and lint cleaning to reduce the number of fibers that break in the gin stand and lint cleaners. Adding moisture to lint that has already been ginned, however, will not increase fiber length (Griffin and Harrell 1957). Other benefits resulting from moisture restoration include reducing the static electricity level of the cotton and reducing the amount of force required to pack and press a bale of cotton (see “Packaging Lint Cotton” in section 5).

Many approaches have been used to restore moisture in cotton fiber. One approach is to atomize water and spray it directly on the cotton. Sometimes a wetting agent is added to the water to hasten its distribution through the cotton. Some gins spray water on the cotton at the lint slide.

Another approach is to use humid air to moisten cotton. The air must be heated to carry sufficient moisture to the cotton fiber. Each pound of air can carry 10 times as much water vapor at 130 °F (0.1118 lb/lb) as it can at 60 °F (0.01108 lb/lb). The vapor pressure of the humid air must be higher than that of the fiber, and this requires a higher air temperature to make the vapor flow to the fiber. As in drying, large differences between air and cotton velocities are important.

The first humid-air systems were installed in plants that used steam engines. Steam from the boiler was introduced into the drying air pipes to eliminate static electricity. A few plants still use this method of humidification. Today humidification systems are commercially available and produce warm humid air of controlled relative humidity. Methods of moisture restoration have included introducing humid air into final-stage tower dryers, extractor feeders, moving-bed conditioners, press battery condensers, and grids in the lint slide and into conditioning hoppers downstream from the distributor.

There is a practical physical limit to the quantity of moisture that may be added to seed cotton. Wetting of the cotton by uncontrolled emissions or by unexpected condensation within machinery and pipes must be prevented, or choking will result. If liquid water is present on the seed cotton mass, gin stand operation will become irregular and may cease altogether. Cotton with fiber moisture of 9 percent or more may be rough in appearance and will not smooth out properly when processed through the lint cleaners. Thus, the recommended fiber moisture level of 6–7 percent is based on production aspects as well as quality aspects.

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Seed Cotton Cleaning and Extracting

R.V. Baker, W.S. Anthony, and R.M. Sutton

The term "seed cotton cleaning" is often used interchangeably by the ginning industry when referring to the process performed by either the total cleaning and extracting system of a gin or by specific types of machines within the system. In its more restrictive sense, "cleaning" refers to the use of various types of cylinder cleaners designed primarily for removal of dirt and small pieces of leaves, bracts, and other vegetative matter. "Extracting," on the other hand, refers strictly to those processes designed to remove large trash, such as burs and sticks, from the seed cotton. Bur machines, stick machines, extractor-feeders, and combination bur and stick machines are examples of extracting-type machinery.

The cleaning and extracting system in a modern gin serves a dual purpose. First, large trash components, such as burs, limbs, and branches, must be extracted from the seed cotton so that the gin stand will operate at peak efficiency and without excessive downtime. Second, seed cotton cleaning is often necessary to obtain optimum grades and market values, especially when ginning high-trash-content cotton. Also, cleaners and extractors help open the seed cotton for more effective drying, which is usually done concurrently with cleaning. The amount of cleaning and extracting machinery required to satisfactorily clean cotton varies with the trash content of the seed cotton, which depends in large measure on the method of harvest (table 5–2).

Table 5–2.
Typical trash levels for machine-picked and machine-stripped cottons[1]

Type of trash	Trash level (lb/bale): Machine-picked[2]	Trash level (lb/bale): Machine-stripped[3]
Burs	34	450
Sticks	9	115
Fine trash[4]	26	110
Motes	30	25
Total	99	700

[1]Typical seed cotton trash levels are based on the results of standard fractionation tests conducted at the USDA–ARS ginning laboratories.
[2]Based on 1,400 lb of first-picked seed cotton with an initial trash content of 7 percent. Second-picked or scrapped seed cotton will contain about twice as much trash as first-picked cotton.
[3]Based on 2,150 lb of stripper-harvested cotton with an initial trash content of 32.5 percent.
[4]Includes soil, leaves, bracts, etc.

Virtually all cotton produced in the United States today is harvested mechanically, either by pickers (74 percent) or strippers (25 percent). A small amount (1 percent) of machine-scrapped cotton is recovered from the ground each year by specially designed salvage machines after the regular harvest. The trash contents of seed cotton vary widely as a result of the different harvesting methods employed and the year-to-year variations in the weather during the cropping season. While these variations in trash level appear to be very wide when viewed from a beltwide perspective, variations within a given ginning community are usually not nearly as great. Most gins process either picked or stripped cotton and are usually equipped with only the amount and type of cleaning and extracting machinery required for the most severe conditions expected in their trade area. For less severe conditions, part of the system should be bypassed to prevent excessive weight losses and to reduce the possibility of overmachining the cotton. Seed cotton cleaning should be restricted to that which is necessary to ensure smooth, trouble-free ginning and that which is needed to obtain optimum bale values.

Cylinder Cleaners

Cylinder cleaners are used for removing finely divided particles and for opening and preparing the seed cotton for the drying and extraction processes (Mayfield et al. 1983). The cylinder cleaner consists of a series of spiked cylinders, usually 4–7 in number, that agitate and convey the seed cotton across cleaning surfaces containing small openings or slots (fig. 5–12). The cleaning surfaces may be either concave screen or grid rod sections, or serrated disks, such as those found in impact cleaners. Foreign matter that is dislodged from the seed cotton by the action of the cylinders falls through the screen, grid rod, or disk openings for collection and disposal. A typical screen is made of 2-mesh woven galvanized wire cloth.

Although screen-type cylinder cleaners have been largely replaced by the more durable grid-type cylinder cleaners, screen-type cleaners continue to be popular in some areas as the last inclined cleaner in the cleaning sequence. Grid sections are normally constructed of 3/8-inch-diameter rods spaced about 3/8 inch apart (fig. 5–13). Grid spacings in excess of 3/8 inch provide additional cleaning, but they also allow more cotton to be lost in the process (Laird et al. 1984). The Trashmaster cleaner (Lummus Industries), however, overcomes this problem by employing a seed cotton reclaimer to recover the cotton from the trash (fig. 5–14). The Trashmaster cleaner uses a 5/8-inch grid spacing.

In another type of machine, the impact cleaner (Continental Eagle Corp.), cotton is conveyed across a series of rotating serrated disks that form a unique revolving grid system (fig. 5–15). This cleaner is also equipped with a cotton reclaiming section. The reclaimer sections used in the Trashmaster cleaner and impact cleaner not only reclaim locks of cotton lost during the initial cleaning but also clean the locks before returning them to the main cotton stream.

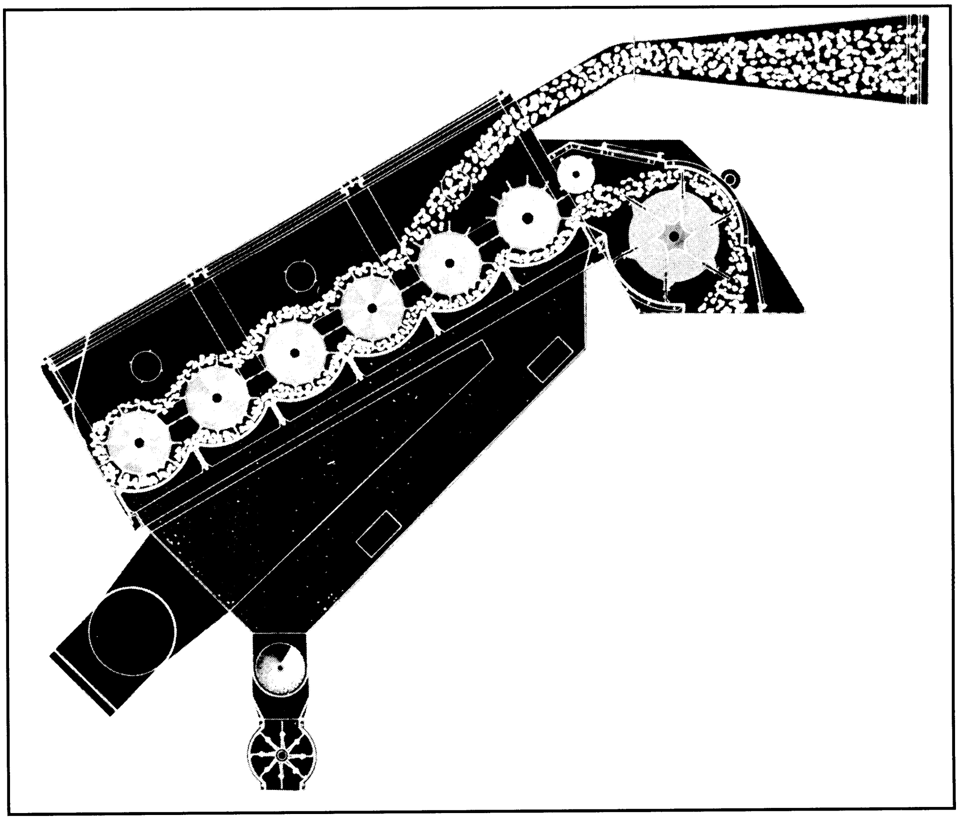
Cylinder cleaners can be further classified with respect to how they are used in the gin. In this respect they are either air line, air-fed, or gravity-fed cleaners (Garner and Baker 1977).

Air line cleaners (fig. 5–16) are usually mounted in a horizontal position in the unloading-system air line. These installations normally permit both the air and seed cotton to pass through the cleaner. In some designs an air line cleaner is combined with a separator to provide both cleaning and seed cotton/air separation (fig. 5–17). Air line cleaners have gained wide acceptance in stripper areas as a means for removing soil particles from seed cotton and for opening partially closed bolls and wads of seed cotton for further cleaning.

Air-fed and gravity-fed cylinder cleaners (fig. 5–18) are usually used immediately ahead of bur and stick extractors or as finishing cleaners above the distributor. The air-fed machines are generally connected to the drying system and serve as an extension of the drying system and as a means of separating seed cotton from the drying air.

Cylinder cleaners are currently manufactured in widths of 6, 8, 10, and 12 ft, with rated capacities of 1-1/2 to 2-1/2 bales/hr/ft of width. For higher capacities two cleaners can be installed in parallel, with each machine cleaning half the seed cotton. Specifications of commercially available cylinder cleaners are given in table 5–3.

Figure 5–12. Six-cylinder, air-fed inclined cylinder cleaner equipped with screen sections (courtesy of Continental Eagle Corporation)



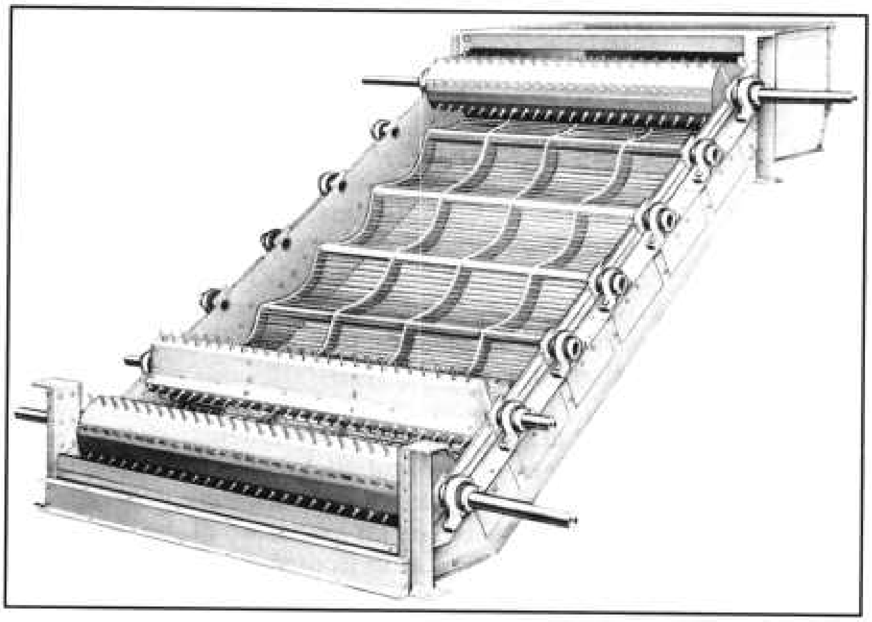


Figure 5–13. Inclined cylinder cleaner equipped with grid-rod sections (courtesy of Continental Eagle Corporation)

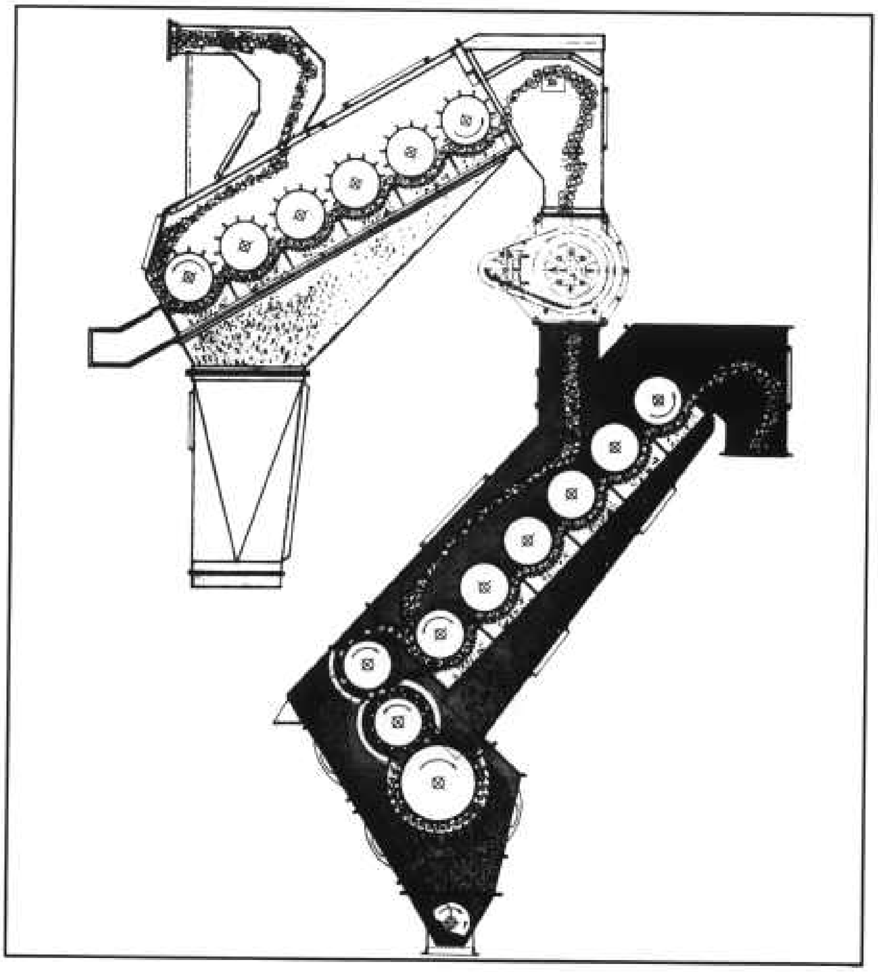


Figure 5–14. Air-fed inclined cylinder cleaner feeding a Trashmaster cylinder cleaner equipped with a reclaiming saw cylinder (courtesy of Lummus Corporation)

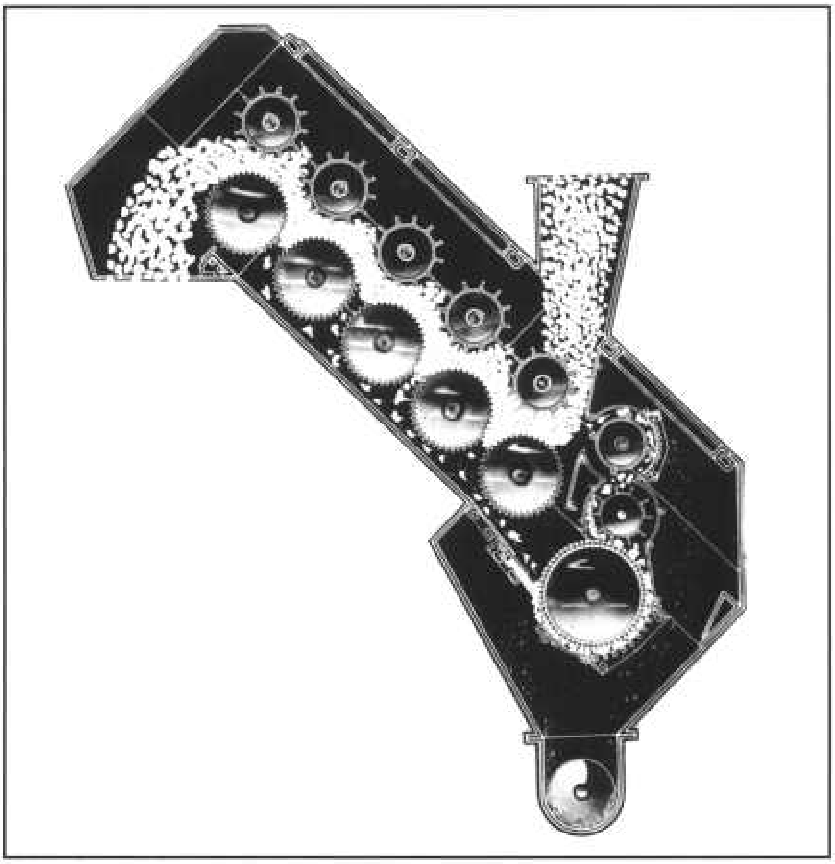


Figure 5–15. Five-cylinder impact cleaner equipped with a reclaiming saw cylinder (courtesy of Continental Eagle Corporation)

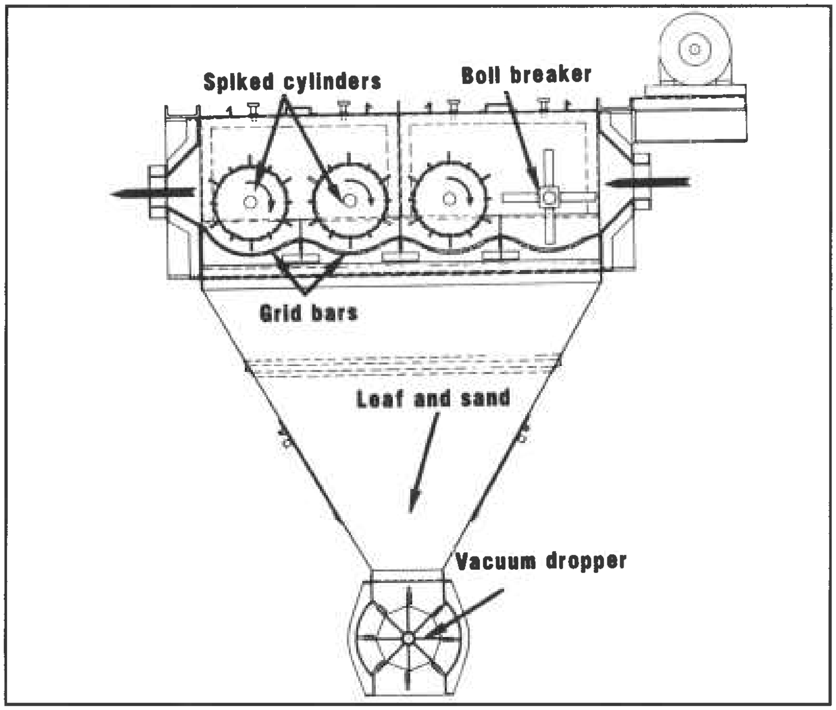


Figure 5–16. Four-cylinder air line cleaner (courtesy of Consolidated Cotton Gin Co., Inc.)

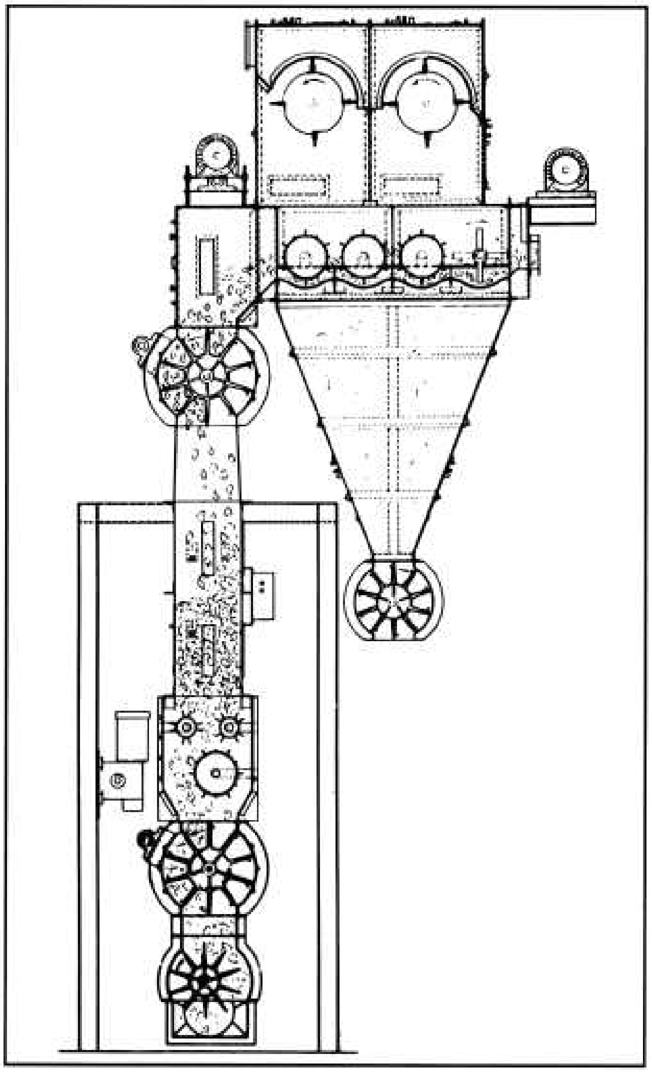


Figure 5–17. Combination separator/air line cleaner feeding seed cotton into feed control unit (courtesy of Consolidated Cotton Gin Co., Inc.)

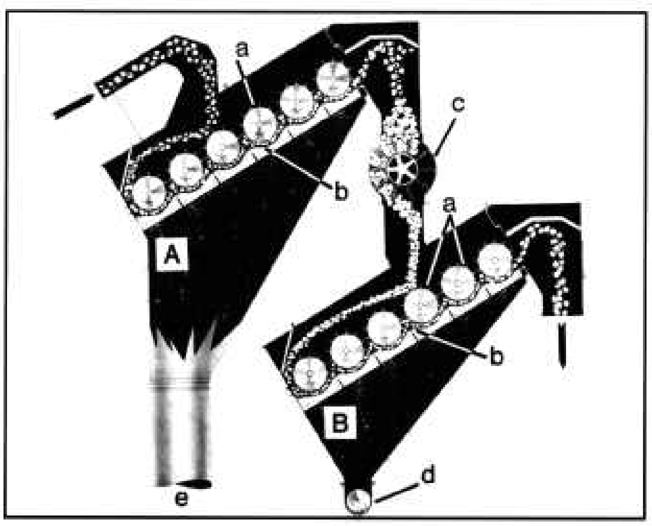


Figure 5–18. *A*, Air-fed and *B*, Gravity-fed inclined cylinder cleaners. *a*, Spiked cylinders; *b*, Grid bars; *c*, Vacuum dropper; *d*, Waste auger; *e*, Air outlet (courtesy of Lummus Corporation).

Table 5–3.
Sizes and characteristics of commercially available cylinder cleaners

Manufacturer and type	Width(s) available (ft)	Cleaning cylinders Number	Speed (rpm)	Approximate capacity per foot of width (bales/hr)	Horsepower requirement per foot of width
Consolidated					
Inclined[1]	6,8,10	7	450	2.0	1.8
Air line[2]	6	4	450	2.5	2.5
Continental Eagle					
Inclined[1]	6,8,10	6	450	2.0–2.5	1.7–2.5
Impact[3 4]	8,10	5	600[5]	2.0–2.5	2.0–2.5
Impact sand remover[3]	10	5	600[5]	2.0–2.5	2.5
Inline separator[2]	6,8	3 or 6	600	2.5–5.0	1.3
Lummus Corporation					
Inclined[1]	6,8,12	6	450	2.0–2.5	2.5
Trashmaster[3 4]	6,8,12	6	450	2.0–2.5	2.5

[1]Air fed or gravity fed.
[2]Air fed.
[3]Gravity fed.
[4]Equipped with reclaimer.
[5]Spiked cylinder speed. Lower cylinders operate at 400 rpm.

Extractors

Bur Machine

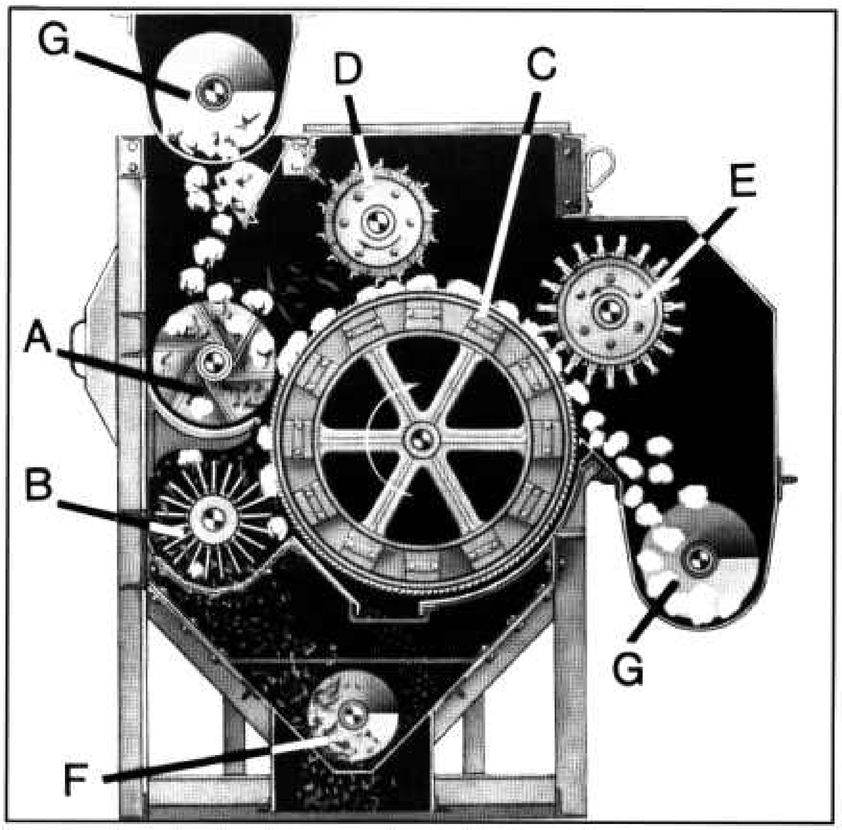
The bur machine was developed in the 1920's in response to hand snapping and mechanical stripping of cotton in Texas. At one time the bur machine was the most popular bulk extractor in use by the ginning industry, especially in stripper-harvesting areas. Because of its limited operating capacity and its low stick removal efficiency, the bur machine has been largely replaced in most modern cotton gins by other more efficient extractors. However, the bur machine continues to be used in many older, low-capacity cotton gins and is important from a historical viewpoint. The bur machine, more than any other machine, made it possible for a gin to satisfactorily handle hand-snapped and machine-stripped cotton (Pendleton and Moore 1967).

The bur machine is based on a dislodging or stripping principle (fig. 5–19). Seed cotton is presented to a large-diameter saw cylinder by a kicker-conveyer equipped with special flippers. Seed cotton adheres to the saw cylinder and is carried past a flighted stripper roller that dislodges burs and sticks from the cotton on the surface of the cylinder. The dislodged material finds its way through the incoming stream of seed cotton to the kicker-conveyer, which moves the material to one end of the machine. At this point the material falls onto a spiked conveyer and is moved back along the entire length of the saw cylinder so that seed cotton can be reclaimed from the dislodged material. Fine particles and dirt sift through a screened trough to an auger located underneath the spiked conveyer.

Bur machines manufactured by the various gin machinery companies are similar in design and size. The saw cylinder is approximately 30 inches in diameter and operates at a speed of 110–140 rpm. The stripper roller is approximately 12 inches in diameter and operates at a 4-to-1 speed ratio with the saw cylinder. The operating speeds of the kicker-conveyer and doffing brush are approximately equal to the speed of the stripper roller.

Gin machinery manufacturers no longer offer the bur machine as a regular or standard product. Bur machines built in the past were available in standard lengths of 10, 14, and 18 ft. When these machines are used today, they are normally the first extractors in the cleaning sequence and are usually preceded by one stage of drying and one cylinder cleaner. Bur machines generally operate at capacities of 0.50–0.75 bale/hr/ft of length. Approximately three-quarter horsepower per foot of length is required to operate these machines.

Figure 5–19. Bur machine. *A*, Kicker conveyor; *B*, Spiked conveyor; *C*, Saw cylinder; *D*, Stripper roller; *E*, Doffing brush; *F*, Hull conveyor; *G*, Cotton auger (courtesy of Continental Eagle Corporation).



Stick Machine

Stick machines use the sling-off action of high-speed saw cylinders to extract burs and sticks from seed cotton by centrifugal force (Franks and Shaw 1959). Seed cotton is fed onto the primary sling-off saw cylinder and wiped onto the sawteeth by one or more stationary brushes (fig. 5–20). Foreign matter and some seed cotton is slung off the saw cylinders by centrifugal force 25–50 times the force of gravity. Grid bars are strategically located about the periphery of the saw cylinder to help control the loss of seed cotton and to aid in the extraction process. However, some loss of seed cotton is inevitable to obtain satisfactory cleaning. Additional saw cylinders are used to reclaim the seed cotton extracted with the burs and sticks. Reclaimer saw cylinders resemble the primary saw but usually operate at slower speeds and are equipped with more grid bars.

Stick machines are usually preceded by one or two stages of drying and at least one stage of cleaning. A preceding cylinder cleaner will open stripped cotton for more efficient cleaning by the stick machine and reduce seed cotton losses. Stick machines may be fed by air or gravity; the trend in recent years has been toward gravity feeding by a separator or cylinder cleaner. Gravity feeding is more uniform and less troublesome than air feeding. Depending on capacity requirements, stick machines may be employed as single units or multiple parallel units.

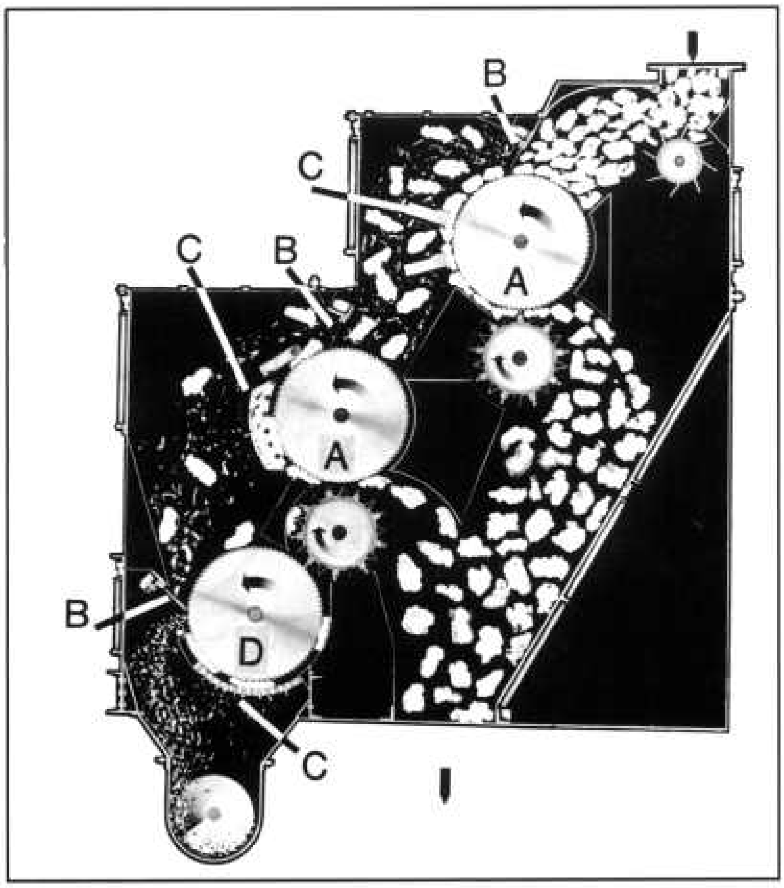


Figure 5–20. Gravity-fed three-saw machine. *A*, Saw cylinders; *B*, Stationary brushes; *C*, Grid bars; *D*, Reclaimer saw cylinder (courtesy of Continental Eagle Corporation).

Commercial stick machines vary widely with respect to number of saw cylinders, grid-bar type and spacing, saw speed and size, and location of stationary brushes. However, all models have at least one primary sling-off saw and one reclaimer saw. Generally, stick machines are classified as either two-saw or three-saw machines (figs. 5–21 and 5–22). In addition, a five-saw stick machine has recently been developed (Baker and Lalor 1989) (fig. 5–23). This machine has outperformed conventional extraction equipment in laboratory and field experiments. The machine, called the multistage extractor, provides three stages of extraction in a single compact machine and shows considerable promise for commercial adaptation.

Table 5–4 summarizes the sizes and characteristics of commercially available stick machines. Machines are available in widths of 6, 8, 10, and 12 ft for single-unit capacities of about 10, 14, 18, and 21 bales/hr, respectively.

Combination Bur and Stick Machine

Cotton gins that process stripper-harvested cotton are frequently equipped with a hybrid type of extractor that combines the best features of the bur machine and the stick machine. These machines are usually identified by various trade names (S&GH, Rescuer, or Stripper/Super III) but will be referred to simply as combination bur and stick (CBS) machines in this discussion.

Figure 5–21. Gravity-fed, two-saw stick machine (courtesy of Lummus Corporation)

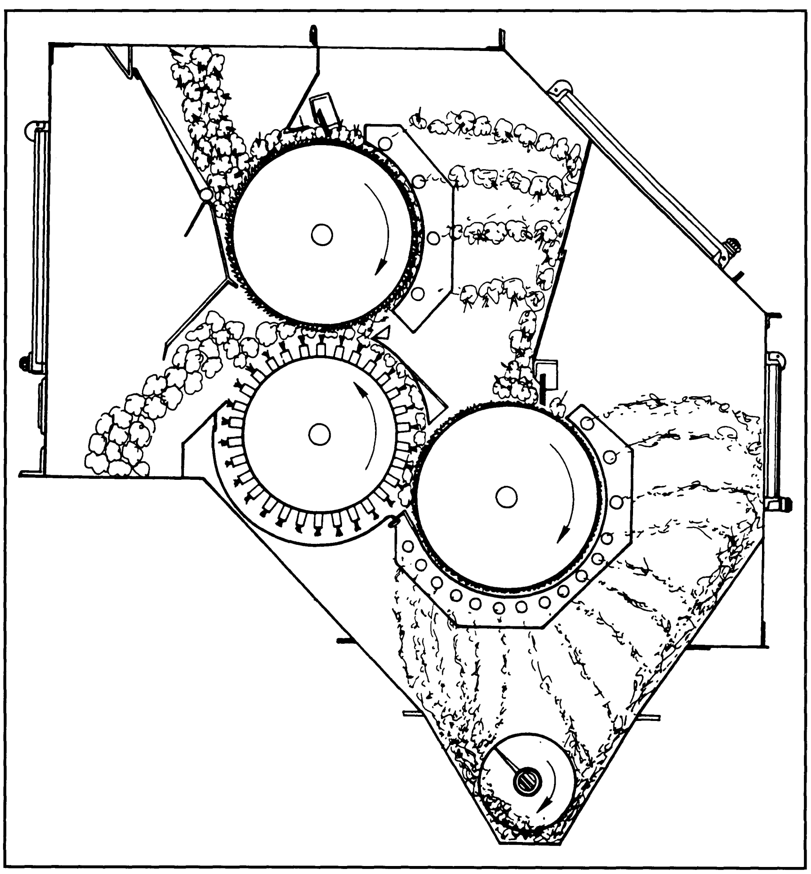


Figure 5–22. Gravity-fed, three-saw stick machine (courtesy of Consolidated Cotton Gin Co., Inc.)

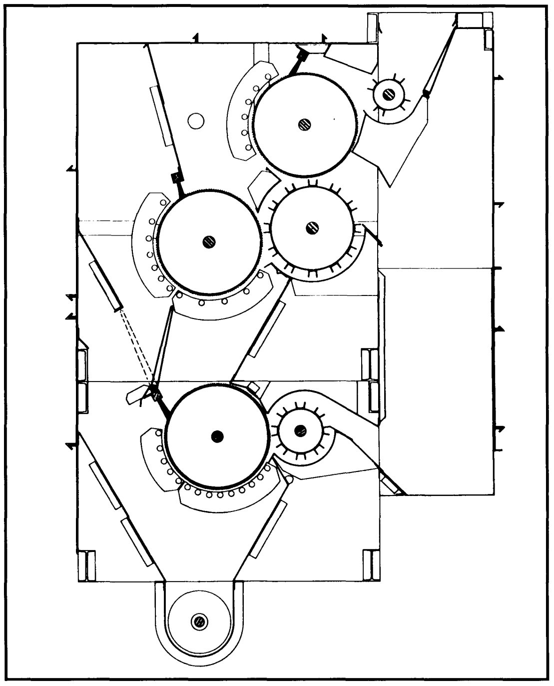


Figure 5–23. Multistage bur and stick extractor. *A*, Sling-off saw cylinders; *B*, Reclaimer saw cylinders; *C*, Doffing brushes; *D*, Large-diameter grid bar sets; *E*, Small-diameter grid bar sets; *F*, Cotton bypass valves (from Baker and Lalor 1989).

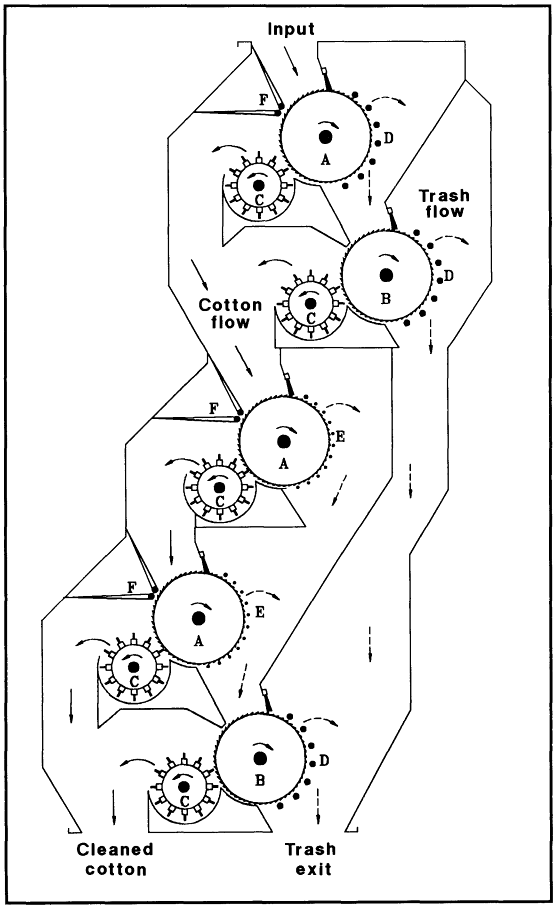


Table 5–4.
Sizes and characteristics of commercially available stick and bur extractors

Manufacturer and make	Widths available (ft)	Primary sling-off saw cylinder Diameter (in)	Speed (rpm)	Approximate capacity per foot of width (bales/hr)	Horsepower requirement per foot of width
Consolidated					
[1 2]Rescuer R220	6,8,10	20	402	1.5–2.0	1.8
[2 3]Rescuer R320	6,8,10	20	402	1.5–2.0	2.5
[2 4]Rescuer 3000	6,8,10	30	150	1.5–2.0	2.5
[2 4]Rescuer 4000	6,8,10	30	150	1.5–2.0	2.5
[2 6]Rescuer 5000	6,8,10	20	320	1.5–2.0	3.8–4.2
Continental Eagle					
[3 5]Little David	6,8	13.75	363	1.0–2.0	1.7
[1 5]Super II	6,8,10	16	320	1.5–2.0	1.9–2.5
[2 3]Super III	8,10	16	340	1.5–2.5	1.9–2.5
[2 4]Stripper	8,10	30	122	1.9–2.0	1.9–2.0
[3 5]H-L-S-T	6,8,10	20	330	1.6–1.8	1.9–2.5
[1 2]Compact	6,8	20	330	1.6–1.8	1.9–2.5
Lummus Corporation					
[1 5]Little Giant	6,8,12	17.50	324	1.5–2.0	1.6–2.0
[2 4]S. & G.H.	6,8,12	30	217	1.5–2.0	3.3

[1]Two-saw stick machine.
[2]Gravity fed.
[3]Three-saw stick machine.
[4]Combination bur and stick machine.
[5]Gravity fed or air fed.
[6]Five-saw stick machine.

The upper section of a CBS machine resembles a bur machine in that it is equipped with an auger feed and trash extraction system and a large-diameter saw cylinder (fig. 5–24). The CBS machine, however, differs from a bur machine in several important respects. The CBS machine is not as wide, although its rated capacity is much higher. Seed cotton is generally fed into a CBS machine across its entire width, as opposed to the end-feeding method used for bur machines. The CBS machine is equipped with a stationary stripper plate whereas the bur machine is equipped with a steel-flighted stripper roller. The upper section of the CBS machine has a foreign matter removal feature that is not found in conventional bur machines. The foreign matter and about one-half of the seed cotton are discharged by sling-off action from the large-diameter saw cylinder to the lower section of the CBS machine. The discharged cotton is cleaned in the lower section, which consists, with minor modifications, of a standard two- or three-saw stick machine (figs. 5–24 and 5–25). Thus, the upper section of the machine serves as a primary cleaner that feeds the lower stick-machine unit (Baker et al. 1982).

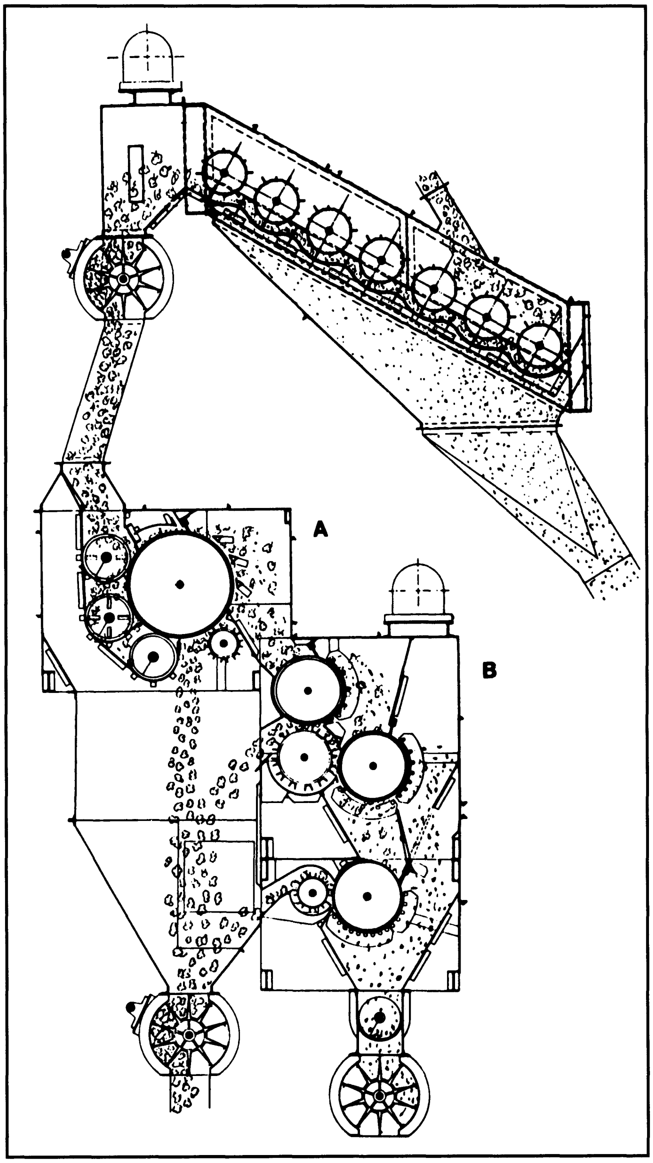


Figure 5–24. Air-fed inclined cylinder cleaner feeding a combination bur and stick machine. *A*, Upper feeding and extracting section; *B*, Lower three-saw stick machine unit (courtesy of Consolidated Cotton Gin Co., Inc.).

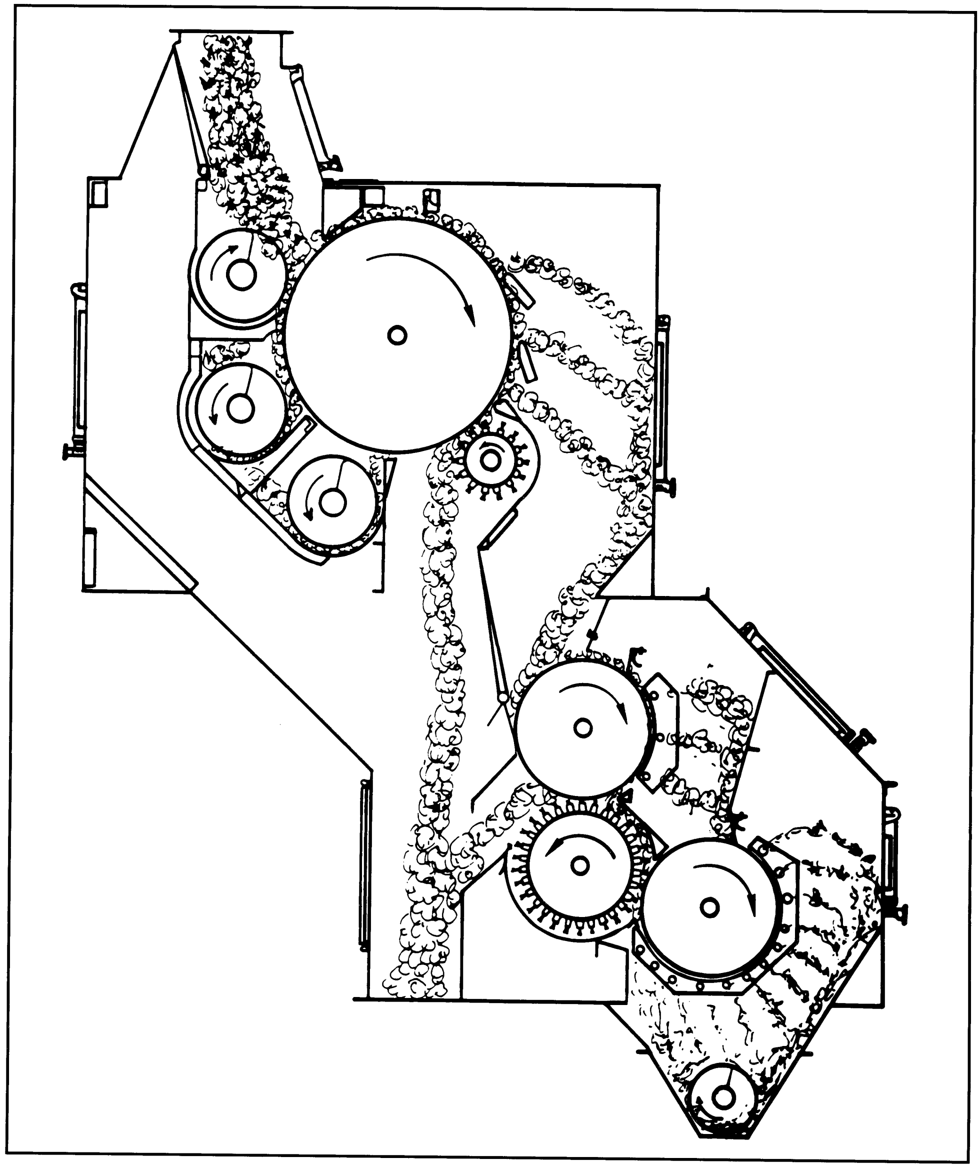


Figure 5–25. Combination bur and stick machine equipped with lower, two-saw stick machine (courtesy of Lummus Corporation)

The CBS machines have gained in popularity since becoming available, particularly at gins processing stripper-harvested seed cotton. These machines are available in widths of 6–12 ft, with operating capacities of 1-1/2 to 2 bales/hr/ft of width (table 5–4). They are usually employed as the first stage of extraction in a seed cotton cleaning system.

Extractor-Feeders

Gin stand feeders with extracting capabilities have been used since the early 1900's (Bennett 1962). Early extractor-feeders used the same stripping or dislodging principle that was used by bur machines. However, after development of the stick machine, most manufacturers abandoned the stripping principle in favor of the stick machine's more efficient sling-off feature. Also,

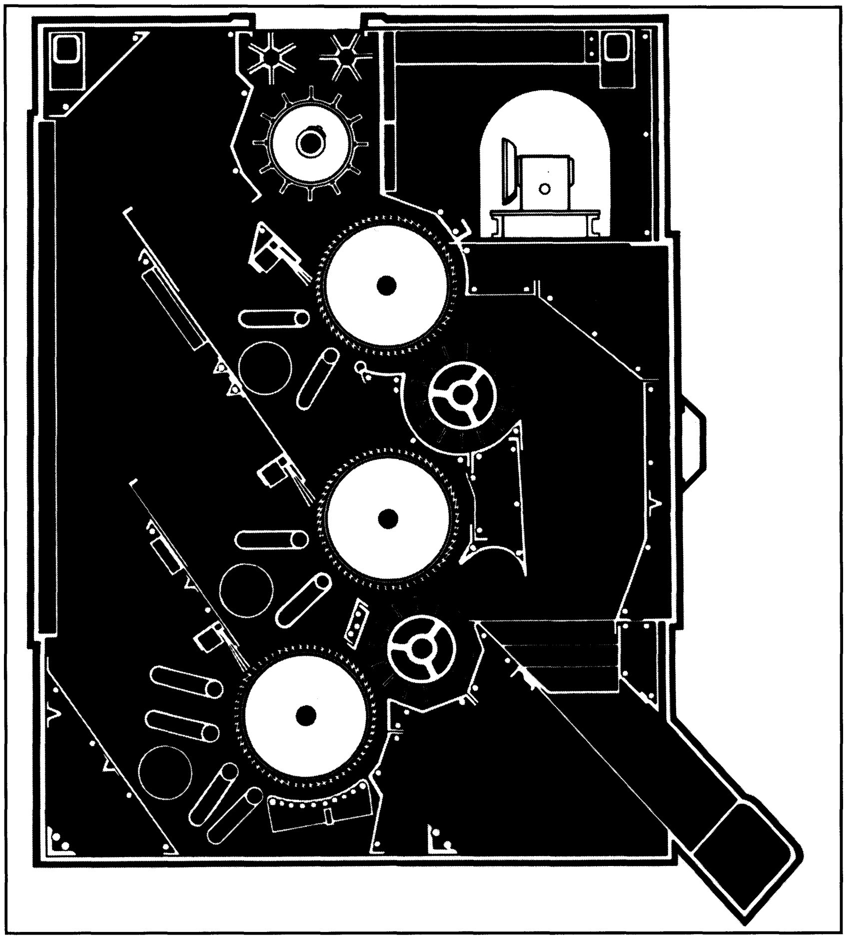


Figure 5–26. Extractor-feeder equipped with extracting and reclaiming cylinders feeding a saw gin stand (courtesy of Consolidated Cotton Gin Co., Inc.)

the introduction of high-capacity gin stands in the late 1950's forced manufacturers to simplify and streamline feeders in order to achieve desired capacities. This was accomplished by adopting the sling-off feature for extractor-feeders (fig. 5–26). In addition, many modern extractor-feeders enhanced fine trash removal by also employing cleaning cylinders similar to those found in an inclined cleaner (figs. 5–27, 5–28, and 5–29).

The primary function of a modern high-capacity extractor-feeder is to feed seed cotton to the gin stand uniformly and at controllable rates, with extracting and cleaning as a secondary function. The feed rate of seed cotton is controlled by the speed of two star-shaped feed rollers located at the top of the feeder directly under the distributor hopper. These feed rollers are powered by variable-speed hydraulic or electric motors and controlled manually or automatically by various interlocking systems within the gin stand. The drive may be designed to automatically start and stop as the gin breast is engaged or disengaged; the system may also be designed to stop feeding seed cotton in cases of gin stand overloads or underloads. Many of the systems are designed to maintain constant seed-roll densities. This is usually accomplished by regulating the speed of the feed rolls in response to feedback

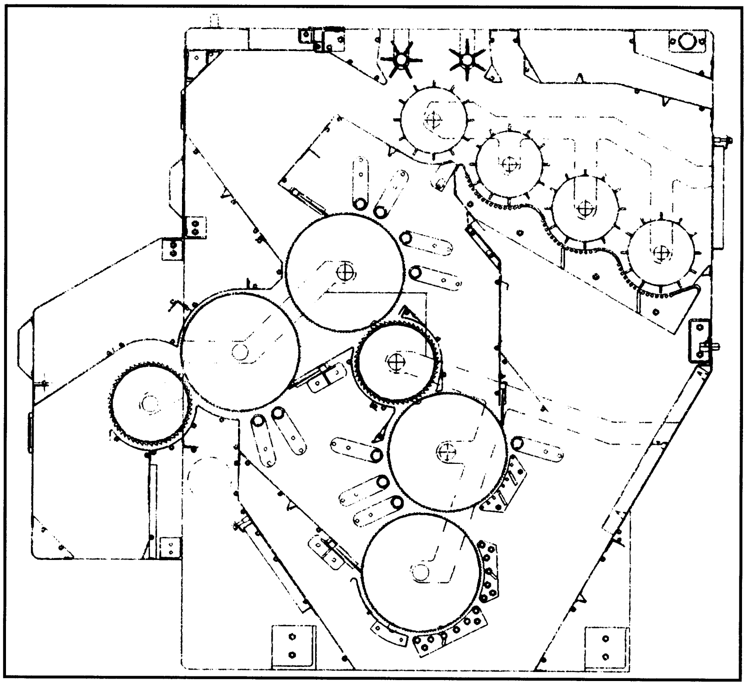


Figure 5-27. Model 9000 extractor-feeder equipped with cleaning, extracting, and reclaiming saw cylinders (courtesy of Continental Eagle Corporation)

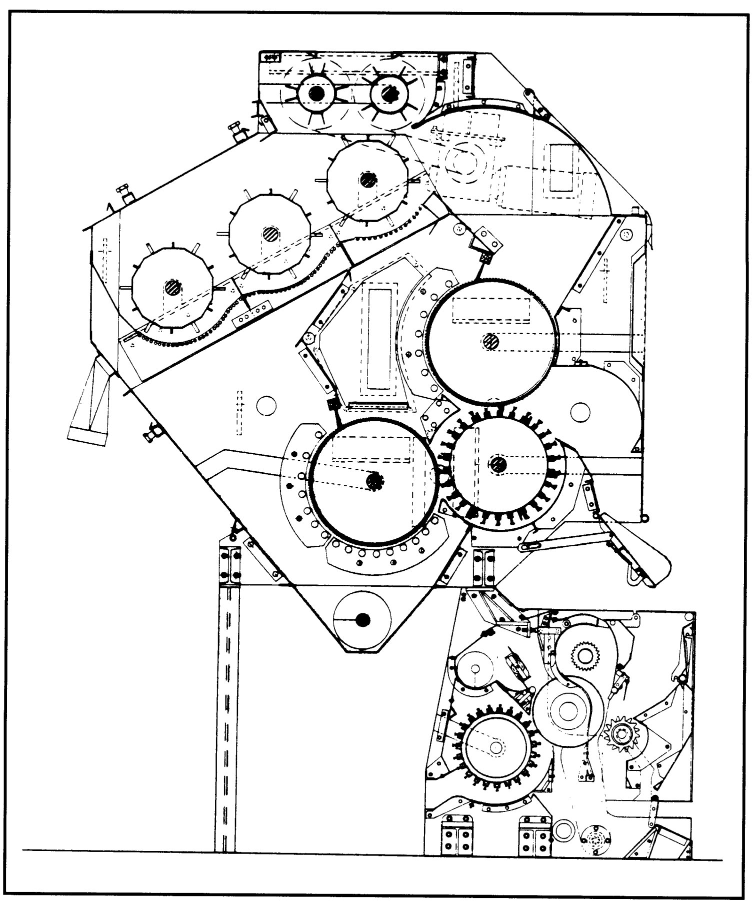


Figure 5-28. Extractor feeder equipped with cleaning and extracting cylinders feeding a saw gin stand (courtesy of Consolidated Cotton Gin Co., Inc.)

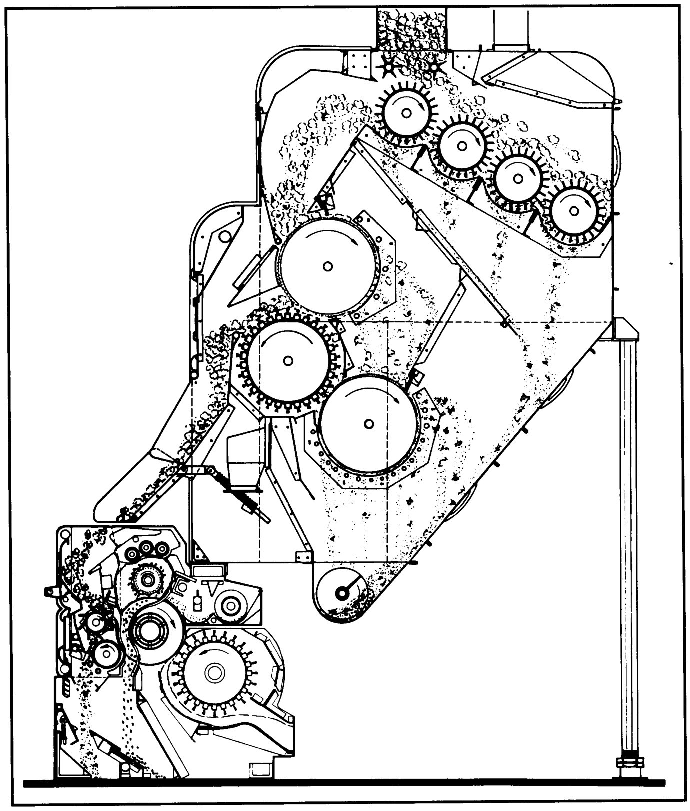


Figure 5–29. Extractor-feeder equipped with cleaning and extracting cylinders feeding a saw gin stand (courtesy of Lummus Corporation)

control signals from the gin stand. The signals are based on monitoring the power consumption of the electric motor driving the gin stand, measuring displacements of the cove board in the seed-roll box, or monitoring the pressure required to drive the hydraulically powered seed-roll agitator.

Cleaning and Extracting Efficiency

The efficiency of a cleaner or extractor depends on many factors, including machine design; cotton moisture level; processing rate; adjustments, speed, and condition of the machine; the amount and nature of trash in the cotton; distribution of cotton across the machine; and the cotton variety. The following discussion on cleaning efficiency is of a general nature and included only as a point of reference. While the efficiency values for various machines quoted in this section are all based on actual test data, one should also recognize that these values depend to some extent on the specific conditions under which the tests were conducted. This information should, however, give the reader an idea of the general efficiency level of each machine and illustrate major differences between various types of cleaners and extractors.

The efficiency data presented in this section are based, for the most part, on the performance of the first machine of a given type in the seed cotton machinery sequence. Machines of the same type used later in the sequence will not be as efficient. For example, the first incline cleaner in a machinery sequence will almost always be more efficient than the second one. This tendency, which also exists for extractors, is due to changes in the trash content of seed cotton as it progresses through the system. Early in the cleaning process, a high percentage of the trash in the seed cotton consists of large, loosely attached particles that are relatively easy to remove. Later in the process, however, the remaining trash particles tend to be smaller and more entangled in the fiber than those encountered initially. Consequently, cleaning becomes more difficult in the later stages of processing.

The total trash removal efficiency of cylinder cleaners is generally low. However, usually they are not used alone but are used in combination with other machines. Cylinder cleaners perform a most useful function in opening the cotton and removing fine trash. Studies using both machine-picked and machine-stripped cottons have shown that the total trash removal efficiency of a six-cylinder inclined cleaner with grid rods generally ranges from 10–40 percent (Cocke 1972, Read 1972, Baker et al. 1982, Anthony 1990). These efficiencies, however, were based on the test cotton's total trash content, including burs and sticks, which were not removed to any great extent by the inclined cleaners. The performance of an inclined cleaner is much more impressive when efficiency figures are based entirely on fine trash levels before and after cleaning. Fine-trash-removal efficiencies as high as 50–55 percent have been reported for both grid-rod and screen-type inclined cleaners when processing stripped and picked cotton (Laird et al. 1984, Anthony 1990).

Trash weight data from tests at the USDA ginning laboratories suggest that the airline cleaner operates at an efficiency that is similar to that of a regular incline cleaner. Some special types of cylinder cleaners have grid or disk openings that are greater than the 3/8-inch openings used in standard incline cleaners. Consequently, these special cleaners should be somewhat more efficient.

The cleaning efficiency of a bur machine depends largely on the amount of trash in the seed cotton. Efficiencies are highest for high-trash-content cotton. When extracting machine-stripped cotton, the bur machine can be expected to be 45–65 percent efficient in removing burs and 30–35 percent efficient in removing sticks (Franks and Shaw 1959, Baker 1971, Baker et al. 1982). Bur machines usually remove only small amounts of fine trash. In many cases, seed cotton will contain more fine trash after extraction by the bur machine than before extraction because the bur machine tends to pulverize large trash particles. This tendency is particularly noticeable when processing seed cotton containing very dry and brittle burs and sticks.

The cleaning efficiency of the bur machine is lower for machine-picked cotton than for stripped cotton. The bur machine can be expected to remove 7–12 percent of the total trash from machine-picked cotton (Read 1972). Fine trash removal from machine-picked cottons is also low.

The cleaning efficiencies of stick machines vary widely, depending on the condition of the seed cotton and on machine design variables. For machine-stripped cotton, a modern commercial stick machine can be expected to remove about 65 percent of the burs, 50 percent of the sticks, and 10–35 percent of the fine trash (Baker 1971, Baker et al. 1982). The total cleaning efficiency for stripped cotton is normally in the 60–65 percent range for the latest models. The efficiency for machine-picked cotton is highly variable because of wide variations in the amount of burs and sticks present in this type of cotton. The total cleaning efficiency can range from about 20 percent for cleanly picked seed cotton to as high as 50 percent for picked cotton containing significant amounts of burs and sticks (Read 1972, Anthony 1990).

The CBS machine is slightly more efficient than a stick machine when processing machine-stripped cotton (Baker et al. 1981). While there is usually little difference between the two machines in stick or fine trash removal, the CBS machine is more efficient in removing burs. Overall, the CBS machine can be expected to remove 4–7 percent more total trash from seed cotton than will a stick machine.

Extractor-feeders are efficient cleaners. Seed cotton is usually well dispersed when it enters an extractor-feeder, and the feed rate through this machine is often lower than the feed rate of other seed cotton cleaning machinery. Studies wherein all seed cotton cleaners prior to the extractor-feeder were bypassed have indicated that the extractor-feeder removes 70 percent of the hulls, 15 percent of the motes, and 40 percent of the remaining trash components and has an overall cleaning efficiency of about 40 percent for machine-picked cotton (Anthony 1974).

Cleaning efficiencies for sequences of four seed cotton machines consisting of a cylinder cleaner, a stick machine, a second cylinder cleaner, and an extractor-feeder range from 40-80 percent, depending on the factors previously discussed. The amount of each type of trash in cotton also varies substantially. Spindle-harvested cotton normally contains 75–150 lb of foreign material/bale of seed cotton. As shown in table 5–2, burs and motes represent the majority of the trash. Each type of seed cotton cleaner is designed to remove different types of trash, and any calculation of machine efficiency is predicated on the type of trash involved.

In a gin's processing system several other machines remove varying amounts of trash even though they are not technically classified as cleaners. Seed-cotton separators, sand removers, module feeding equipment, and some types of dryers remove substantial amounts of fine trash and soil particles. The huller front of most gin stands removes limited quantities of burs, sticks, and fine trash from the seed cotton prior to ginning. In addition, the gin stand's moting system removes significant amounts of motes and fine trash during the ginning process. Since trash removal is somewhat incidental in this type of machinery, very little attention has been given to its cleaning efficiency.

Normal Machine Sequences

Machinery sequences normally used for cleaning picked and stripped seed cotton were devised not only to provide the required cleaning and extracting but also to mesh the machines conveniently. The number and types of machines required under most ginning conditions were determined from research studies conducted at the USDA ginning laboratories (Baker et al. 1977, Anthony et al. 1988). The exact arrangement of the machinery, however, evolved gradually over the years largely in response to the functional requirements for handling seed cotton in the dryers and between the various machines. Typically, machine-picked seed cotton is processed by the following machines in the sequence listed: a dryer, cylinder cleaner, stick machine, dryer, cylinder cleaner, and extractor-feeder. The normal sequence for machine-stripped cotton is an air line cleaner, dryer, cylinder cleaner, combination bur and stick extractor, dryer, cylinder cleaner, stick machine, and an extractor-feeder.

More detailed information on machinery requirements is available in this handbook (see ginning recommendations for processing machine-picked and machine-stripped cotton in section 9).

Repair and Maintenance

Cleaning and extracting machinery is subject to considerable wear from the large volumes of trash and soil particles contained in the seed cotton. Also, seed cotton occasionally contains rocks, scrap metal, large woody debris, or other foreign objects that can damage various machine components. Consequently, all machinery should be inspected periodically for excessive wear or damage. Worn or damaged machine parts should be repaired or replaced on a timely basis and adjusted to manufacturer's specifications to maintain peak operating efficiency. Worn machinery or improper machine adjustments can also adversely affect fiber quality. Poor doffer settings or worn brushes, for example, can cause recirculation of cotton around the saw cylinder. Recirculation contributes to low grades and overmachining. Any machine problem that interferes with smooth, uniform feeding can also adversely affect quality. It is imperative that seed cotton be uniformly distributed across the width of cleaning machinery to avoid poor cleaning and excessive cotton losses.

Commonly encountered wear and damage problems include (1) worn or bent grid rods, screens, or drum spikes in incline cleaners, (2) excessively worn, bent, or missing channel saws and stationary brushes in extractors, (3) worn or damaged doffing brush cylinders in extractors or reclaimers, (4) rough or corroded grid bars in extractors, (5) damaged or ill-fitting doors, lids, or access panels, and (6) worn or improperly tensioned belt and chain-drive assemblies. Careful attention to these and other related problems will greatly improve the gin's operating efficiency and reduce costly downtime.

Many of the chokeups that occur in cleaning and extracting machinery are caused by faulty rubber flights in seed cotton droppers and trash vacuum droppers. For smooth, trouble-free operation, it is imperative that vacuum droppers be well maintained (see "Pneumatic and Mechanical Handling Systems" in section 6 for information on separators and vacuum droppers). Other operational problems can be traced to seed cotton or trash that builds up inside machinery over time and interferes with the smooth flow of material through the machinery. All machinery should be inspected and cleaned daily to preclude these types of problems.

Extreme care should be taken when cleaning and servicing gin machinery. Cleaners and extractors contain many rotating cylinders that can severely injure or kill negligent employees. ***Never attempt to unchoke, clean, or service any machine while it is operating!*** For safety, a machine should be completely stopped and locked out electrically before opening access doors, lids, or panels and before removing guards on belts, chains, or gears. After machines are serviced, access doors and panels and machinery guards should be replaced before restarting the machine.

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Gin Stands

E.P. Columbus, D.W. Van Doorn, B.M. Norman, and R.M. Sutton

The gin stand is the heart of the ginning system. The capacity of the system and the quality and potential spinning performance of the lint depends on the operating condition and adjustment of the gin stand (Wright and Moore 1977).

All gin stands are adjusted at the factory, but the settings may change during handling and shipping. It is important, even in new gins, to check all settings and to make necessary adjustments in accordance with the manufacturer's instructions. A number of adjustments are common to nearly all gin stands, and attention to these details will contribute to better operation of the gin and preservation of lint quality (Anthony 1985). Some of the more important adjustments and settings for various makes and models of gins are shown in figures 5–30 through 5–37. Machinery manufacturers will furnish up-to-date manuals that give detailed instructions on installing, adjusting, and operating their gin stands.

Before new equipment is installed or adjusted, the gin stand should first be placed in correct alignment with the other machinery, leveled, and firmly bolted to the floor. After the settings are checked and the necessary adjustments are made, the gin breast should be placed in the ginning position and the saw cylinder rotated by hand to make sure that all parts are clear and that no foreign objects are within the gin stand. As in any other gin equipment, the motor should be phased before the drive belts are connected to ensure that the motor is rotating in the correct direction. Before the gin stand is run at full speed, the drive motor should be "jogged" to see if all

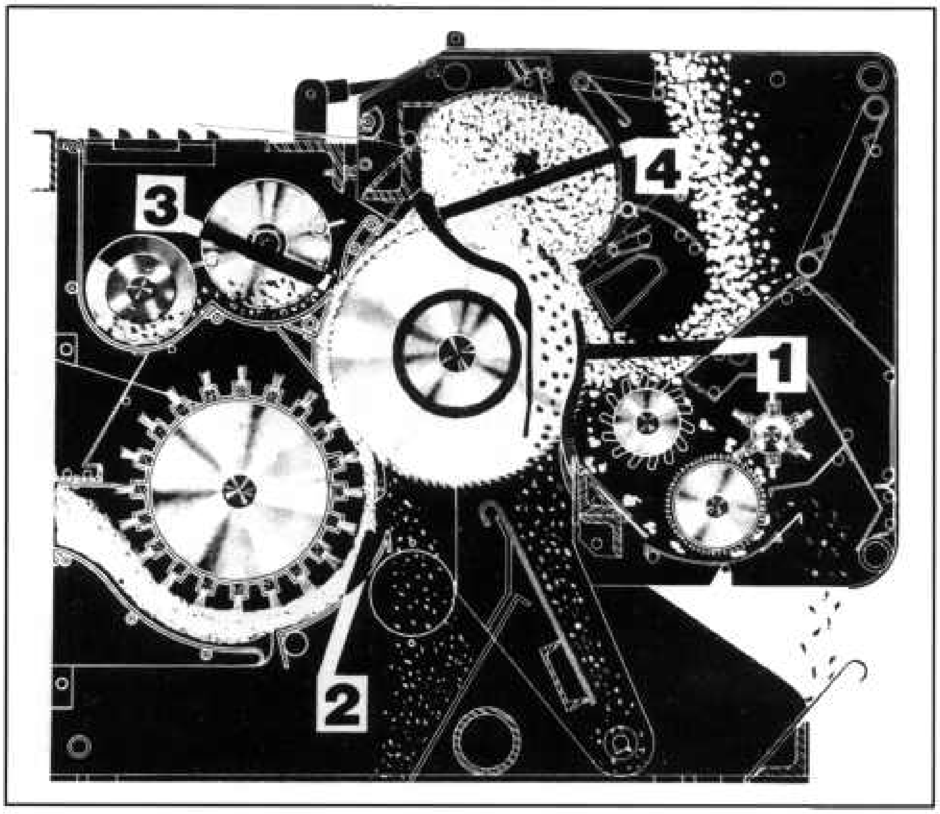


Figure 5–30. Important settings and adjustments for Continental Eagle 141 saw-brush gin. *1*, Saw projection through huller rib, 3/8"; *2*, Gravity mote board to brush, 1-1/2"; *3*, Overhead mote board to saw, 1/16"; *4*, Ginning point to point of rib, 2". Saw speed, 625 rpm; brush speed, 1,850 rpm (courtesy of Continental Eagle Corporation).

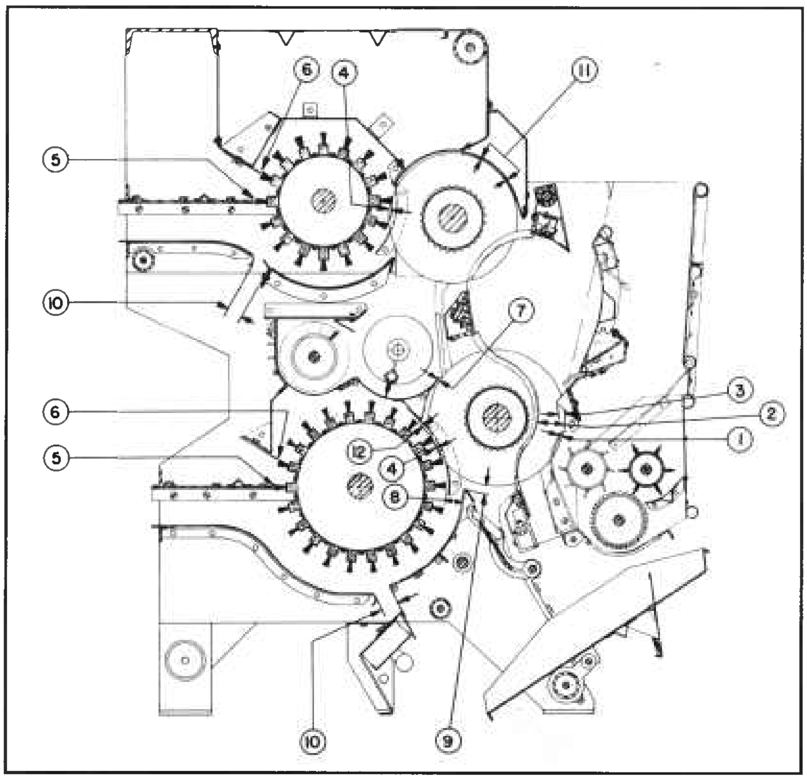


Figure 5–31. Important settings and adjustments for Hardwicke-Etter Regal 224 dual saw-brush gin. *1*, Saw projection through split rib, 3/16"; *2*, Saw projection through gin rib, 2-3/8"; *3*, Huller knife projection into saw, 1/2"–5/8"; *4*, Brush to saw, throat of tooth; *5*, Lower cutoff plate to brush, 1/16" or closer; *6*, Upper cutoff plate to brush, 1/8"; *7*, Mote board to saw, 1/16"–3/32"; *8*, Mote board to brush, 1-1/16"; *9*, Lower mote board to saw, 3/4"; *10*, Airgap, nonadjustable; *11*, Upper scroll to saw, 3/32"; *12*, Top brush scroll to brush, 1/4" minimum. Upper saw speed, 695 rpm; lower saw speed, 650 rpm.

Figure 5–32. Important settings and adjustments for Lummus Imperial 88, 108, 128, and 158 saw-brush gins. *1*, Saw projection through huller rib, 1/2"–9/16"; *2*, Brush to saw, depth of sawteeth; *3*, Mote board to saw, 1/4"; *4*, Mote board to brush, 1–3/4"; *5*, Overhead mote lip to saw, 1/8". Saw speed, 830 rpm; brush speed, 1,770 rpm (courtesy of Lummus Corporation).

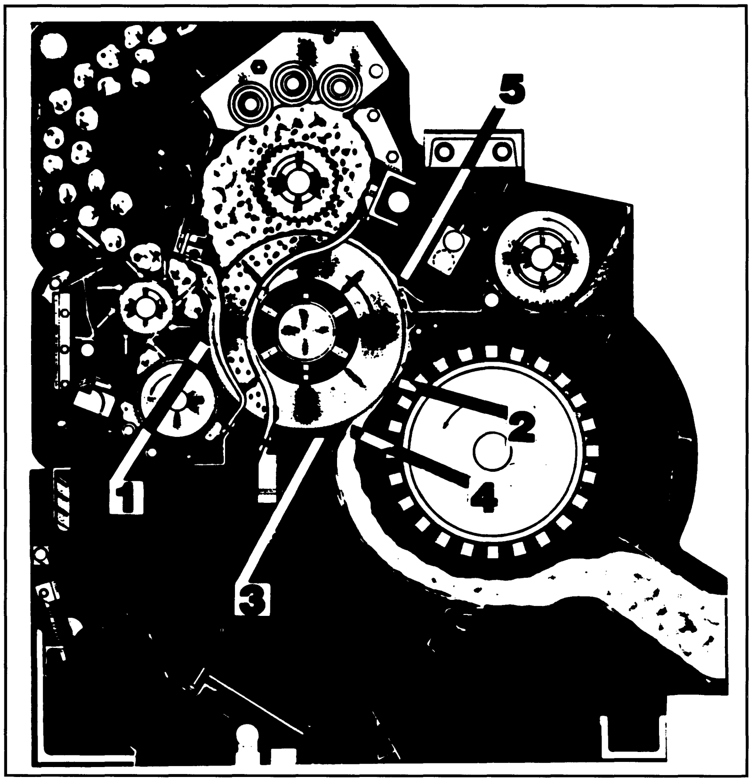
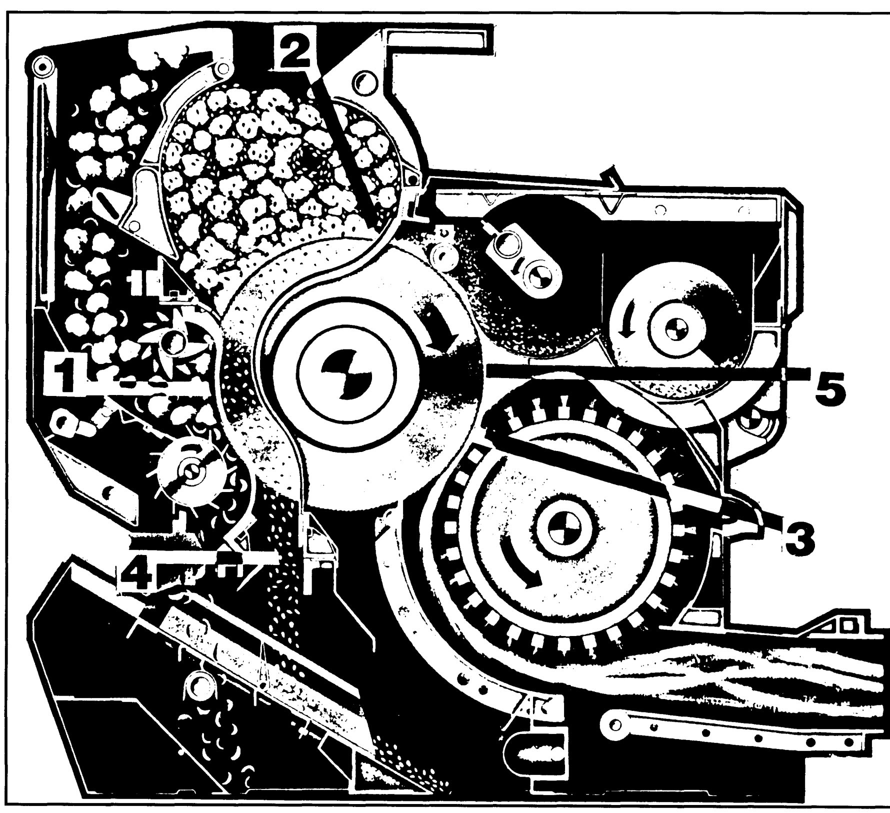


Figure 5–33. Important settings and adjustments for Murray 142–18 brush gin. *1*, Saw projection through huller rib, 3/16"; *2*, Ginning point to point of rib, 2"; *3*, Brush to saw, depth of sawteeth; *4*, Root of huller rib to ginning rib, 3"; *5*, Mote bar to saw, 3/32". Saw speed, 545 rpm (courtesy of Continental Eagle Corporation).



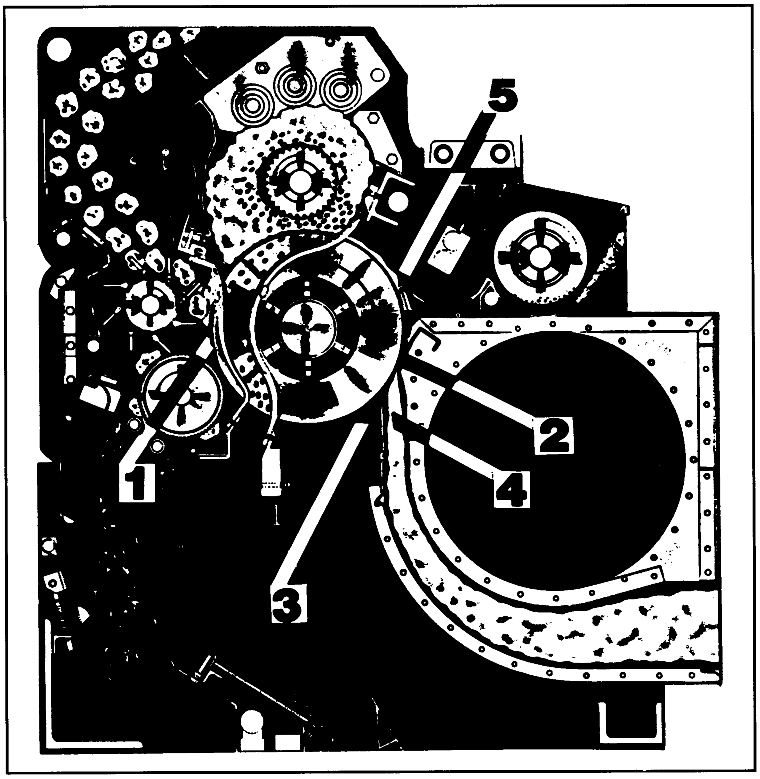


Figure 5–34. Important settings and adjustments for Lummus Imperial 88, 108, 128, and 158 saw airblast gins. *1*, Saw projection through huller rib, 1/2"–9/16"; *2*, Airblast nozzle to saw, 1/16"; *3*, Airblast mote board to saw, 1/4"; *4*, Airblast throat opening, 1-13/16"; *5*, Overhead mote lip to saw, 1/8". Saw speed, 830 rpm; airblast pressure, 16"–19" of water column (courtesy of Lummus Corporation).

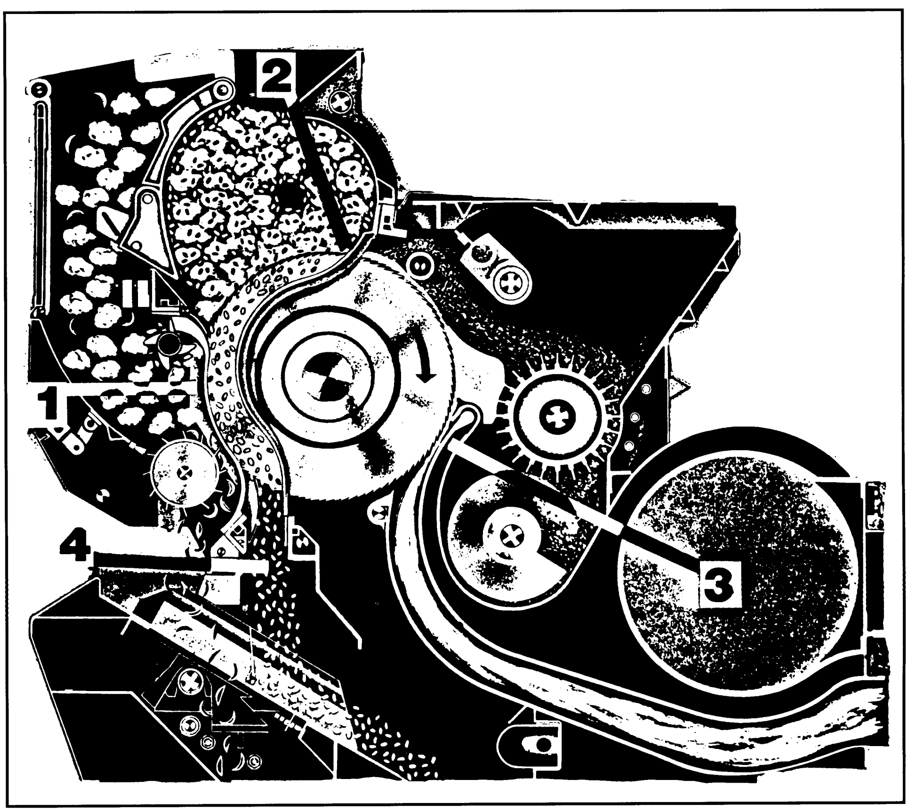


Figure 5–35. Important settings and adjustments for Murray 120–18 airblast gin. *1*, Saw projection through huller rib, 3/16"; *2*, Ginning point to point of rib, 2"; *3*, Airblast nozzle to saw, 3/32"; *4*, Foot of huller rib to ginning rib, 3". Saw speed, 456 rpm; airblast pressure, 10"–16" of water (courtesy of Continental Eagle Corporation).

Figure 5–36. Important settings and adjustments for Consolidated Cotton Gin Company, Inc., brush-type gin (112 and 164 saw). *1*, Saw to seed finger assembly, 1-27/32"; *2*, Saw to picker roller, 19/32"; *3*, Saw to bottom "cut off," running clearance; *4*, Brush to "cut off," running clearance; *5*, Saw to mote wiper plate tip, 9/32"; *6*, Saw to mote bar, 1/8–3/16". Saw speed, 841 rpm; brush speed, 1,799 rpm (courtesy of Consolidated Cotton Gin Co., Inc.).

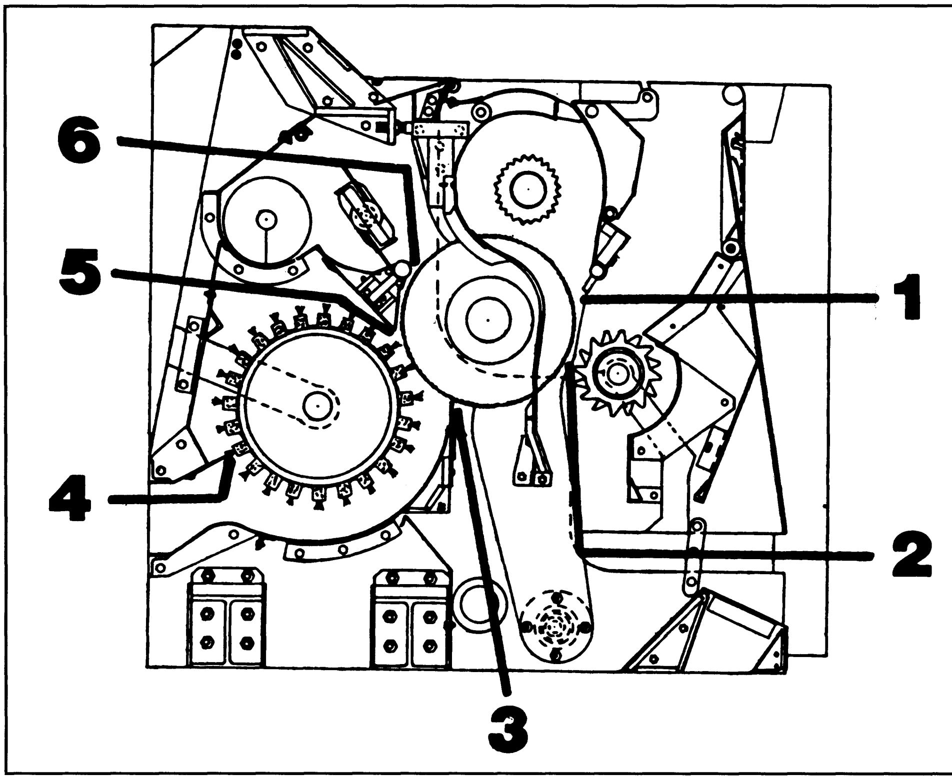
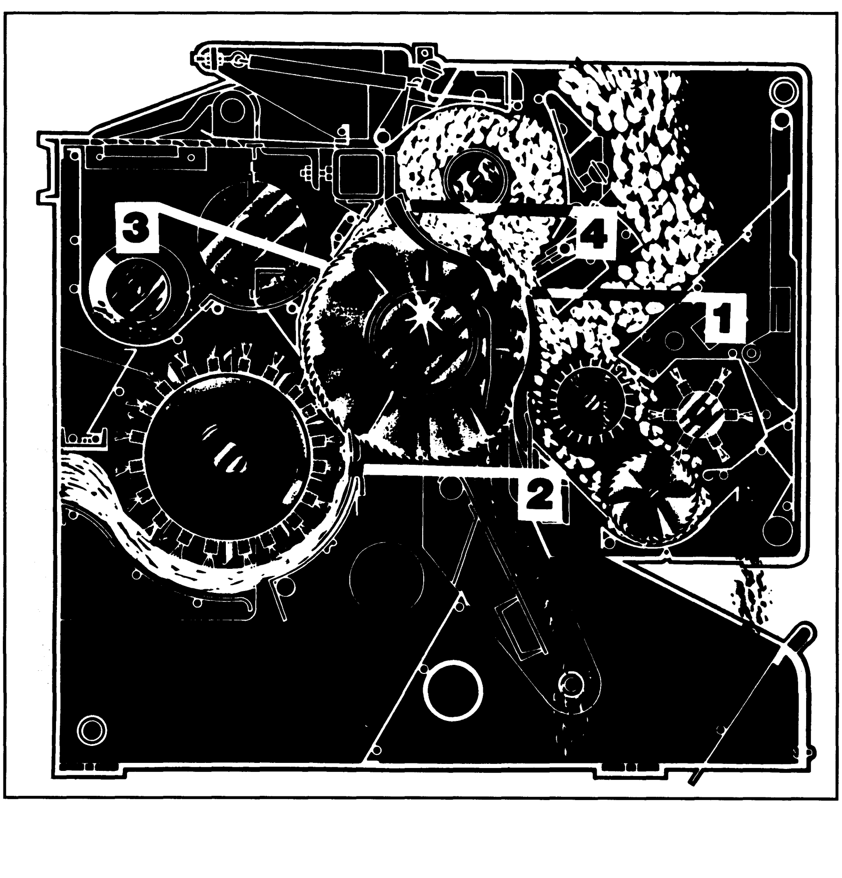


Figure 5–37. Important settings and adjustments for the Continental Eagle 141 Double Eagle and 161 Golden Eagle saw brush-type gin. *1*, Saw projection through huller rib, 3/8"; *2*, Gravity mote board to brush, 1-1/2"; *3*, Overhead mote board to saw, 1/16"; *4*, Ginning point to point of rib, 2". Saw speed, 615 rpm; brush speed, 1,552 rpm (courtesy of Continental Eagle Corporation).



cylinders of the gin stand are free to turn and to see if the cylinders are rotating in the proper direction. Then the motor should be turned on to check the saw speed. It is very important that the saw speed be very close to the recommended speed, since as slight a variation as 20–25 rpm from the manufacturer's recommendations can make an appreciable difference in performance.

Gin manufacturers generally have made their gin stands safe to operate. However, gin stand operation can still be hazardous unless proper precautions are taken. Other than the manipulation of the normal operating controls, ***no adjustments or maintenance should be attempted while the gin stand is in operation.*** The gin stand should always be stopped and the power turned off and locked out before making adjustments to the settings or attempting maintenance work.

Gin Breast

After new gin stands are installed or old ones are repaired, the lateral adjustment of the breast should be correct. The saws should be positioned in the center of the rib slots. After visual inspection, the saw cylinder should be rotated slowly by hand to make certain that none of the saws rub the ribs.

On removal from a gin stand, the gin breast should be identified with that gin stand, and special care should be taken to be sure the breast is reinstalled in that same gin stand.

When a broken rib is replaced, care should be taken to install the replacement so that the size of the saw opening is the same on each side. A matched set of ribs installed by well-equipped and experienced personnel will usually give better service than unmatched sets installed without proper gauges and jigs.

The breast should never be moved into ginning position when seed cotton is in the roll box unless the saws are running. To do so may damage the ribs or buckle the saws.

On many gins the position of the picker roller is adjustable (see item 2, fig. 5–36). In some cases it can be adjusted by means of a ratchet lever while the gin is in operation. Generally speaking, the roller should be set as far away from the saw or huller ribs as possible without the gin dropping cotton. The closer the picker roller is set to the huller ribs, the less space there is for hulls to fall out and the more the saw will break the hulls up and pull small pieces into the roll box with the cotton. Some of the latest model high-capacity gin stands are designed without huller ribs. Different adjustments must be made on these gins, and the individual manufacturer's instructions should be followed. The huller ribs should not be removed from an older model gin stand without consulting the manufacturer, as unsafe conditions will result when the huller ribs are removed without providing proper guards.

The seed fingers, or lambrequin, should be set as wide open as possible but close enough that the seeds will be cleaned (cleaned seeds should be devoid of long fibers). When building up a new roll, the seed fingers should be closed and then slowly opened as wide as necessary to allow the cleaned seeds to fall out of the roll box. Holding seeds in the roll box longer than necessary will reduce the ginning rate and cause tight seed-roll operation, which reduces the value of the cotton and may cause seed damage.

The relation of the saws to the ribs is critical. The manufacturers manual should be consulted to determine which of the dimensions shown in figure 5–38 should be checked to ensure proper saw-rib relations.

Gin Saws

Saws should be checked to make sure they are properly trained (that is, running in the middle of the rib slots) and running at the recommended speed. If the distance from the point where the saws project through the ginning rib to the top of the rib is not correct, capacity will be reduced and fibers may be damaged. The distance the saws project through the huller ribs should also be checked. If the saws project too far, an excess of hulls and sticks will be pulled into the roll box. If the saws do not project far enough, ginning capacity will be reduced, seed cotton will fall out of the front, and the huller ribs may become choked.

The pitch and shape of the saw teeth are also important in maintaining capacity and cotton quality. Griffin and McCaskill (1969) found that neps were increased by dull or broken saws and by the use of saws whose diameter had been reduced by one-sixteenth of an inch after repeated sharpening. To ensure good ginning, the teeth must pass through the ribs at the proper angle. The leading edge of the tooth should be parallel with the rib, or the point of the tooth should enter the ginning rib slightly ahead of the throat (fig. 5–39). If the saws are improperly filed or the saw-rib relationship is improperly adjusted so that the throat of the tooth enters the rib ahead of the point, the resulting cutting action will reduce capacity and break fibers and may cause choking at the top of the ginning ribs. In many instances, the moting action of gin stands is affected by the saw teeth being tilted too far forward or backward.

Saws should be examined frequently, and bent teeth should be straightened or even broken off and filed smooth so that lint will not hang in them. Lint that cannot be doffed will tend to collect in the low part of the gin ribs. If this lint is allowed to accumulate, the friction of the saw will cause the lint to catch fire and perhaps damage the saws. A heat-damaged saw that wobbles cannot be retrained and should be replaced or removed immediately. Lint collected in the bottom rib slot can also be caught by the saw when the stand is disengaged, possibly breaking the ribs and damaging the saws.

The number of bales that can be ginned between replacing or sharpening the saws depends on the type of cotton being handled and on the metallurgical properties of the saws. Rough cotton causes more wear on gin saws than

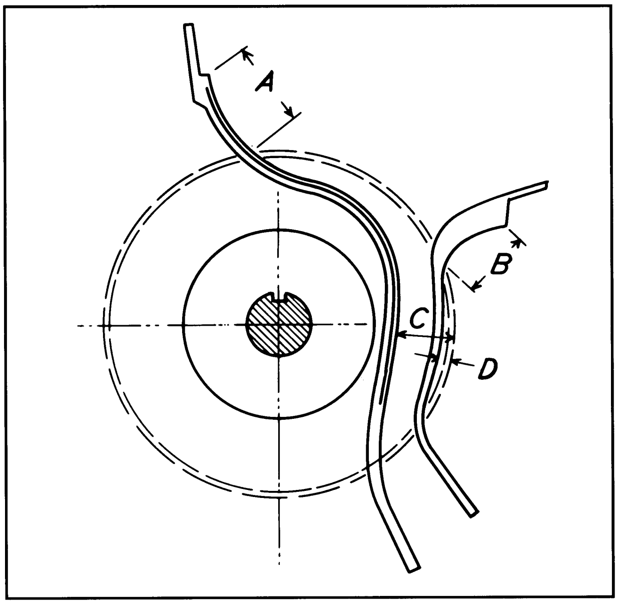


Figure 5–38. Critical saw-rib dimensions (A, B, C, and D) that vary with manufacturer's make and model. Specifications should be followed so that cotton quality and gin stand capacity will be maintained.

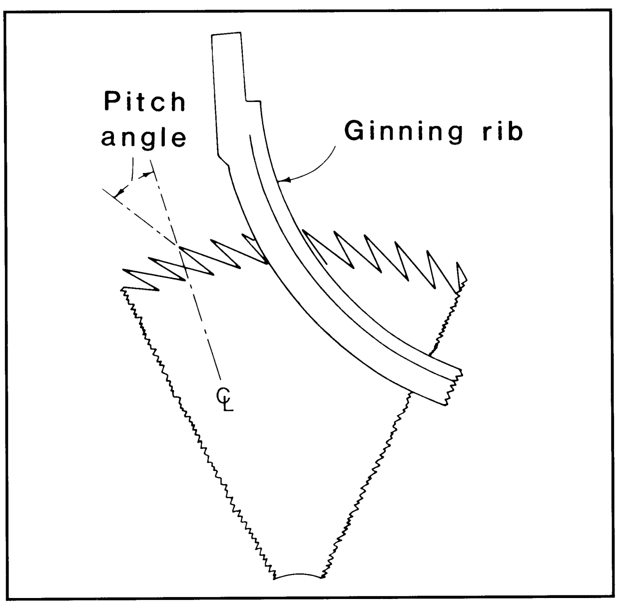


Figure 5–39. Leading edge of the tooth should enter the ginning rib parallel to the rib surface, or the point of the tooth should lead the throat slightly. Saws should never be filed or breast adjusted so that the throat leads the point of the tooth. *CL*, Centerline.

clean cotton, regardless of the type of steel used. Modern gin saws are made from stronger, more durable steel than older saws and thus have a much longer useful life. High-capacity gin stands equipped with such saws can gin 3,000–8,000 bales/stand before changing. Processing trashy cotton and keeping maintenance at a minimum will make more saw changes necessary. Also, excessive spindle twists will cause teeth to break. The general practice in high-capacity ginning is to replace rather than attempt to sharpen worn saws. Sharpening of saws is practicable and is an economical alternative to replacement if the dull saws are in good shape and have few broken teeth. However, sharpening reduces the diameter of the saw; after several sharpenings the saws will no longer fit in the proper relation to the fixed rib structure, and gin capacity may be reduced. Many ginners find it uneconomical to continue to use saws that have been sharpened more than three or four times. Extreme care should be used to maintain the original tooth shape and pitch during sharpening. The edges of the teeth should be deburred after sharpening.

When changing saws, it is best to keep saws of the same diameter on a mandrel. If new saws are used with saws that have been reduced one thirty-second of an inch in diameter, it is not possible to adjust the gin breast properly to all of the saws. Saws that have been reduced by one-sixteenth of an inch in diameter must be replaced. At least one spare saw cylinder should be on hand during the ginning season.

Doffing System

Brushes

For proper doffing, the brush should mesh to the depth of the sawtooth (fig. 5–40). Belts driving the brush must be kept tight to maintain proper speed for doffing and to provide sufficient air velocity in the lint flue so that backlashing is prevented.

The brushes should be examined periodically and replaced if the bristles are badly worn. They should be returned to the manufacturer for repair if facilities are not available for rebalancing them. Brushes that are out of balance will cause excessive vibration and bearing wear.

When brushes in the stand are replaced, care should be taken to secure the shaft and bearings so that lateral motion or "end play" is eliminated and to adjust the setting of the brush to the saw, mote board, and cutoff plate

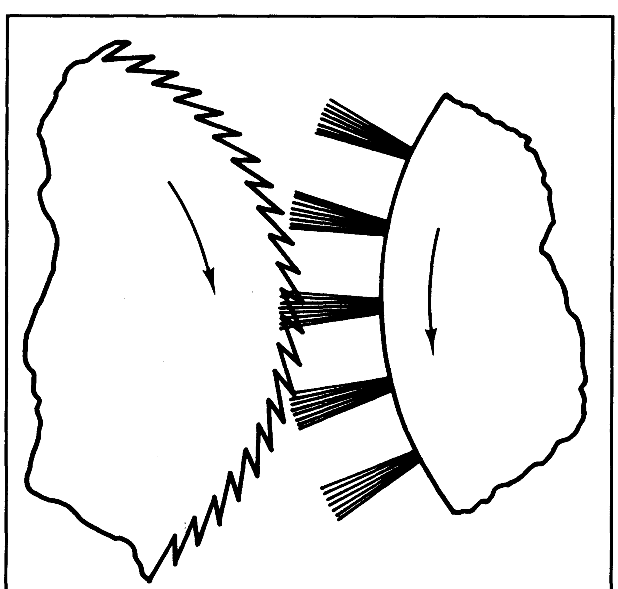


Figure 5–40. For proper doffing, the gin brush should be set to mesh with the depth of the sawteeth.

according to the manufacturer's recommendations (see figs. 5–30 through 5–37).

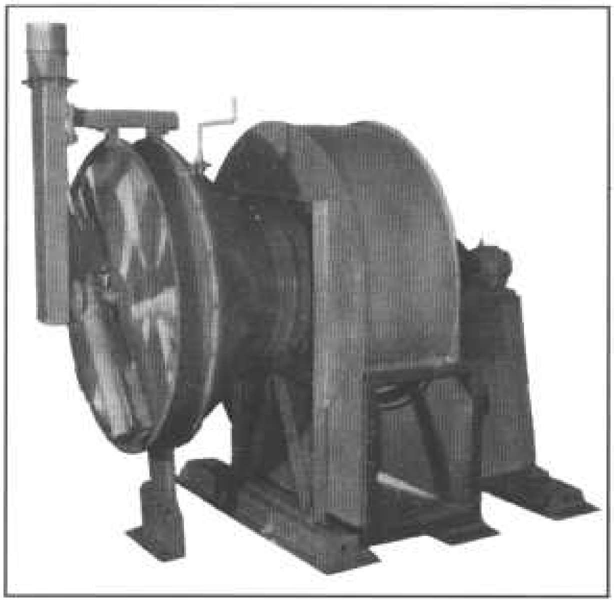
If worn brushes are to be replaced, consideration should be given to replacing the paddle-type brush cylinder with a solid-face brush cylinder. The solid-face brush is a more efficient doffer, produces more air at a given speed than a paddle brush, and produces much less noise than a paddle brush (see "Noise in Cotton Gins" in section 11). Because of the different air handling characteristics of the solid-face brush, adjustment may be necessary in brush speed and/or the speed of the conveying fan between the gin stand and lint cleaners.

Airblast Nozzles

Manufacturers give specific instructions for setting the airblast nozzle for each model of gin stand; these instructions should be followed to ensure proper doffing and moting. The nozzle should be kept clean and free of tags, and care should be taken to avoid damaging the nozzle or the gin saws when removing a saw cylinder. Many tags may be prevented by periodically removing the cap from the end of the airblast trunk and starting the fan to blow out the accumulation of dust and fly. ***Face protection should be worn at all times!***

The airblast pressure should be checked frequently to make certain that correct doffing pressure is being maintained. For most gins, the correct static pressure will be in the range of 15–19 inches of water, measured at the nozzle. Sufficient pressure should be maintained to give proper doffing without wasting power. Manufacturers can supply an adjustable airblast fan valve by which the air pressure can be readily adjusted (an airblast fan is shown in fig. 5–41). It is important that the airblast fan inlet be equipped

Figure 5–41. Hardwicke-Etter airblast fan equipped with intake control vanes, screen, and screen wiper (PN-5234)



with a fine-mesh screen to keep foreign matter out of the fan and that the screen be kept clean. It is best to locate the inlet high above the floor, away from the lint fly, and to equip the inlet with a well-designed automatic screen cleaner.

Moting System

Modern gin stands are equipped with both overhead and gravity moting systems. The seals on the overhead moting system, whether dropper wheel or roller type, should be kept in good condition. In some gins, pressure is maintained in the overhead moting chamber, and the system will not operate properly if the seals leak excessively. Honeydew and green, wet lint sometimes cause motes to be sticky and build up on the moting bars, wiper flights, and roller seals. Such a buildup drastically reduces moting system effectiveness. Under extreme conditions the buildup will cause chokage in the gin ribs. When sticky motes are encountered, the moting bars and seals should be cleaned frequently with fine steel wool, and the surfaces should be coated with a light textile oil, silicone, or teflon spray. The mote system should never be cleaned when the gin saw is turning. The gin saws should be stopped and the power locked out before cleaning the moting system.

Proper adjustments are also important on gin stands having a mote board in the gravity moting system (fig. 5–37). The mote board should be adjusted by opening it slowly until it starts dropping lint, then closing it slightly. The wider the mote board can be opened without losing lint, the more effectively the system will operate. On most gin stands the screws for adjusting the mote board are near the end saws. The gin must be stopped and the power locked out before attempting to adjust the mote board.

Ginning Effects on Quality

The high-capacity and super-high-capacity gin stands now on the market are the result of years of research and experience on millions of bales of cotton. They will give good service as long as they are properly adjusted, kept in good condition, and operated at design capacity. Manufacturer's capacity recommendations for 1962 through 1989 model gin stands handling good, clean, dry seed cotton are given in table 5–5. If gin stands are overloaded, the quality of the cotton may be reduced. Griffin (1977, 1979) showed that short fiber content increased as the ginning rate was increased above the manufacturer's recommendation. He also found that short fiber increased as saw speed increased. Mangialardi et al. (1988) found that increasing the ginning rate resulted in increases in Uster yarn imperfections. Seed damage can also result from increasing the ginning rate, especially when the seeds are dry. Watson and Helmer (1964) found that variations in ginning rate and seed moisture could cause seed damage ranging from 2–8 percent in gin stands. Thus, it is paramount to maintain the gin stand in good mechanical condition, to gin at recommended moisture levels, and to not exceed the capacity of the gin stand or other components of the system.

Table 5–5.
Manufacturer's specifications and capacities for various makes and models of gin stands[1]

Manufacturer/ Model year	Saw cylinders (number)	Saw diameter (inches)	Saws (number)	Capacity (bales/ hour)	Horsepower
Continental[2]					
1962	1	12	120	3–3.5	25
1962	1	16	79	4	40
1962	1	16	119	6	50
1973	1	16	93	5	50
1973	1	16	141	7.5	75
[3]1979	1	16	141	12	125
[3]1988	1	16	161	15	150
Consolidated Corp					
1986	1	12	164	10	75
1988	1	12	112	6–8	50
1989	1	12	164	12	100
1989	1	12	112	8.5	75
Hardwicke-Etter Co.[4]					
1958	1	12	120	3	40
1958	1	12	100	2.5–3	30
1962	2	[5]11-3/4, 12	178	4–4.5	50
1962	2	[5]11-3/4, 12	224	6–8	75
1974	2	[5]11-3/4, 12	200	4.5–5	75
1974	2	[5]11-3/4, 12	252	6.5–9	100
Lummus Corporation					
1962	1	12	88	4–5	60
1964	1	12	128	8	75
1973	1	12	108	7	75
1973	1	12	158	10	100
1988	1	12	108	8.5	75
1988	1	12	158	12	125
1989	1	12	158	15	150
Murray[2]					
1962	1	12	120	3	40
1962	1	18	80	4–5	50
1968	1	18	94	5–6	60
1968	1	18	120	6	60
1973	1	18	142	8	75
[3]1980	1	18	94	6–8	75
[3]1982	1	18	142	8–10	100

[1]Data are averages and will vary considerably for different types of cotton.
[2]Now marketed under Continental Eagle Corporation.
[3]Equipped with seed tube.
[4]No longer in business.
[5]Bottom saw, 12 inches; top saw, 11-3/4 inches.

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Lint Cleaning

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Lint cleaners were developed specifically for removing leaf particles, motes, grass, and bark that remain in cotton after seed cotton cleaning, extracting, and ginning. They were developed and improved in conjunction with the transition from manual to mechanized harvesting of cotton during the 1950's. Virtually all gins in the United States have lint-cleaning facilities, and over four-fifths of the gins have two or more stages of lint cleaning (U.S. Bureau Census 1979). The lint cleaners now being marketed are of two general types, flow-through air type and controlled-batt saw type.

Flow-Through Air Lint Cleaner

The flow-through air lint cleaner, commercially known as the Air Jet/Super Jet, Centrifugal Cleaner, or Super Mote Lint Cleaner, has no saws, brushes, or moving parts (Van Doorn 1954). It is usually installed immediately behind the gin stand but in some cases is installed behind the first saw-type lint cleaner. Loose lint from the gin stand or saw lint cleaner is blown through a duct within the chamber of the air lint cleaner. Air and cotton moving through the duct change direction abruptly as they pass across a narrow trash-ejection slot (fig. 5–42). Foreign matter that is heavier than the cotton fibers and not too tightly held by fibers is ejected through the slot by inertial force. The amount of trash taken out by the air jet is controlled by opening and closing this cleaning slot, which can be completely closed. Vane-axial

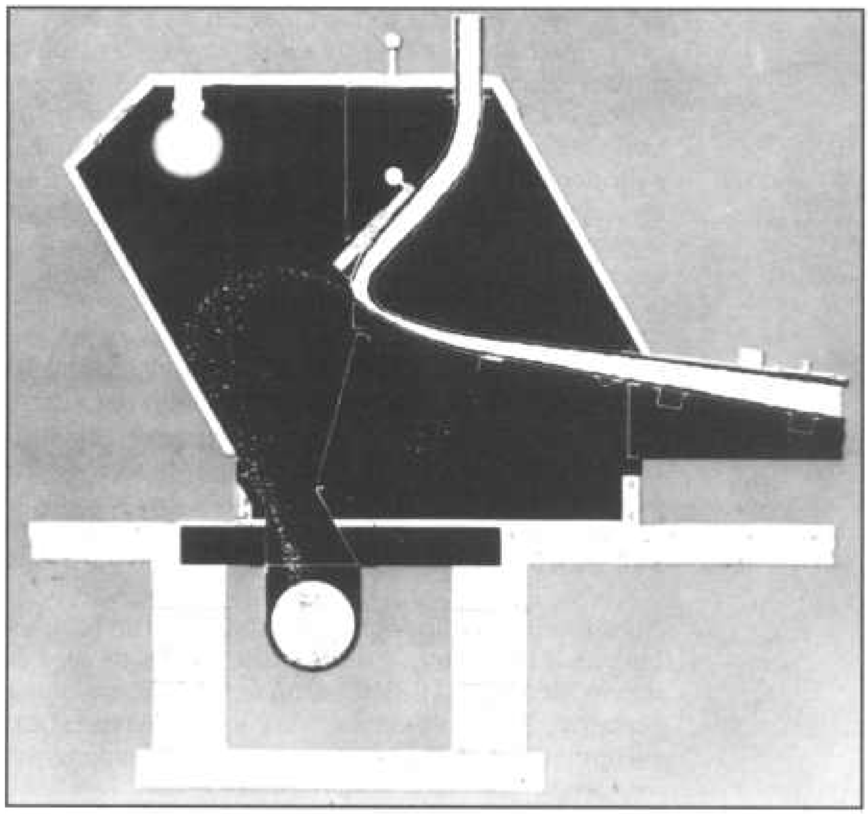


Figure 5–42. Unit flow-through air lint cleaner, usually located behind the gin stand (SuperJet lint cleaner, courtesy of Lummus Corporation)

fans pull the air and lint to suction condensers, where the air and cotton are separated. A critical factor in the operation of air cleaners is that a vacuum of 2–2.5 inches of water must be maintained in the duct on the discharge side of the cleaner. In most cases the gin stand brush or air blast system provides the pressure to accelerate the air, lint, and trash to a high velocity as it enters the trash ejection slot. In some cases, particularly in roller gin installations, boost air is added to maintain an air velocity of 10,000–12,000 ft/min at the cleaning nozzle.

Flow-through air lint cleaners are less effective in improving the grade of cotton than saw lint cleaners because these air lint cleaners do not comb the fibers. However, air lint cleaners do remove less weight from the bale. Fiber length, fiber strength, and neps are unaffected by the air lint cleaner (Griffin and McCaskill 1957, St. Clair and Roberts 1958). This type of cleaner is commonly used in roller gins processing extra long staple cotton.

Controlled-Batt Saw Lint Cleaner

The controlled-batt saw cleaner is now the most common lint cleaner in the ginning industry. Lint from the gin stand or another lint cleaner is formed into a batt on a condenser screen drum. The batt is then fed through one or more sets of compression rollers, passed between a very closely fitted feed roller and feed plate or bar, and fed onto a saw cylinder (fig. 5–43). Each set of compression rollers rotates slightly faster than the preceding set and causes some thinning of the batt. The feed roller and plate grip the batt so that a combing action takes place as the saw teeth seize the fibers; the feed plate clears the saw by about one-sixteenth inch. The teeth of the saw cylinder convey the fibers to the discharge point. While the fibers are on the saw cylinder, which may be 12–24 inches in diameter, they are cleaned by a combination of centrifugal force, scrubbing action between saw cylinder and grid bars, and gravity assisted by an air current.

The fibers may be doffed from the sawteeth by a revolving brush (figs. 5–44 and 5–45) or air suction. When brush doffing, the tip speed of the brush should be 1.5–2.0 times the tip speed of the saw. The principal features and settings of saw lint cleaners used in most gins are given in table 5–6, and their recommended installations and power requirements are given in table 5–7. These data for some of the older model saw lint cleaners are listed in older versions of the "Cotton Ginners Handbook" (Stedronsky 1964, Mangialardi 1977).

An important factor in the operation of the cleaner is the condition of the batt as it is fed to the saws. If the batt is thicker on one side of the condenser drum or if it is too thin or broken, the lint cleaner will not operate properly. Poor batt conditions can also cause chokes and may damage the equipment. A good batt can be obtained only by having the proper air bal-

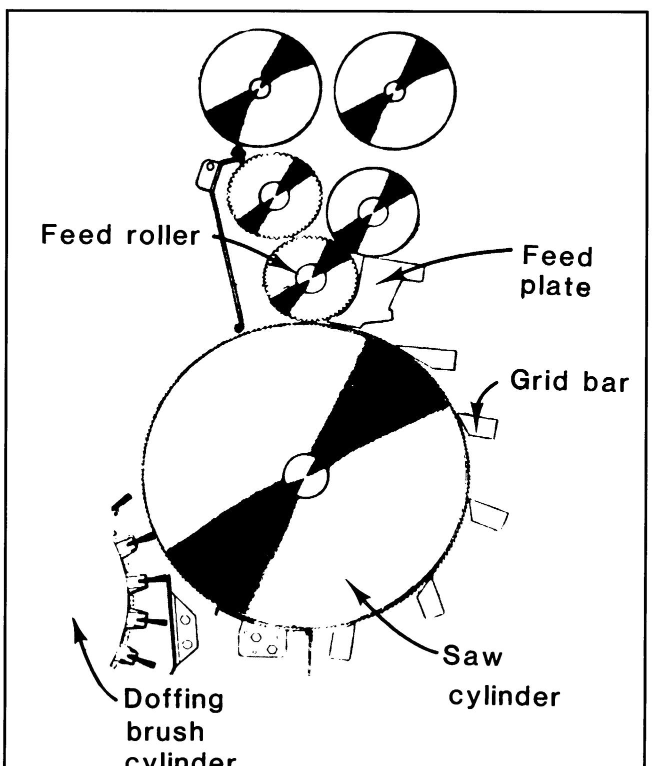


Figure 5–43. Feed works of a controlled-batt saw lint cleaner (Cleanmaster lint cleaner, courtesy of Continental Eagle Corporation)

Figure 5–44. Unit controlled-batt saw lint cleaner with brush doffing (Lummus model 86 or 108 lint cleaner, courtesy of Lummus Corporation)

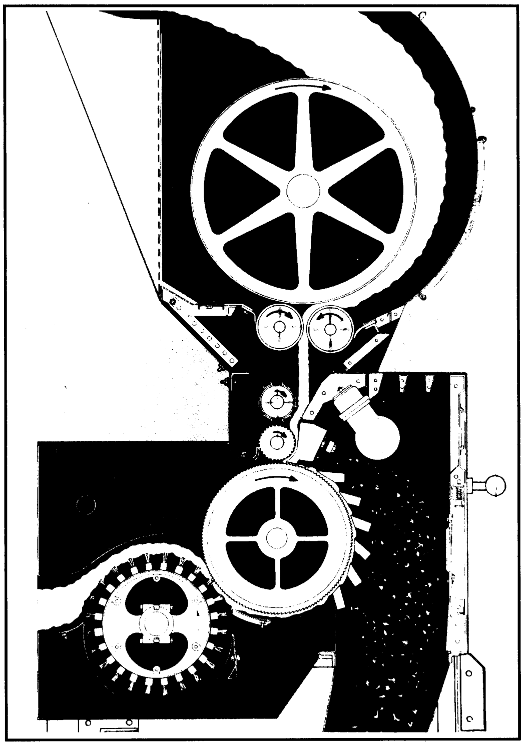


Figure 5–45. Unit controlled-batt saw lint cleaner (Continental model 24-D Golden Eagle lint cleaner, courtesy of Continental Eagle Corporation)

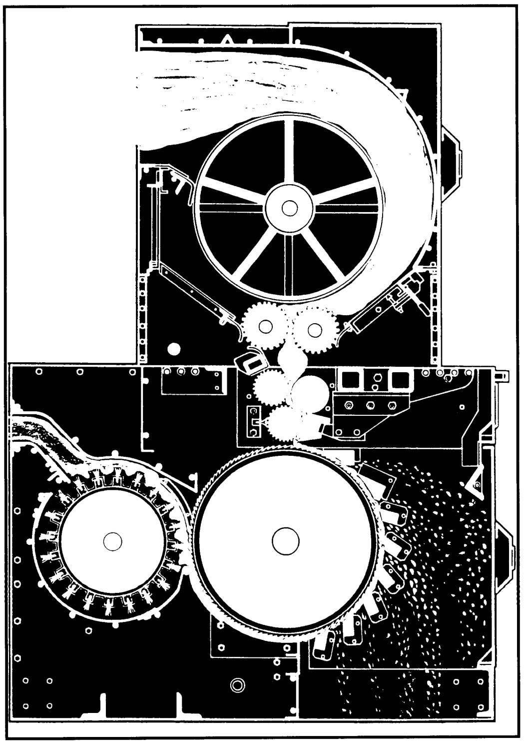


Table 5–6.
Principal features and settings of saw lint cleaners

Manufacturer and make	Saw diameter (inches)	Saw speed (rpm)	Grid bars (number)	Feed-roller diameter (inches)	Settings[1]: Feed plate to saws (inch)	Settings[1]: Feed roller to feed plate	Settings[1]: Grid bar to saw (inches)	Doffing system
Consolidated HGM Corp.								
Multisaw Super 86 inch:								
Top saw.............	16	1,220	7	4-1/2	5/64	0.010 inch, floating spring loaded	0.030	Brush, 18-inch diameter
Bottom saw...........	24	1,040	6	—	—	—	0.042	—
Super 66 inch.........	16	1,200	7	4-1/2	5/64	0.010 inch, floating spring loaded	0.030	Brush, 18-inch diameter
Super 86 inch.........	16	1,200	7	4-1/2	5/64	.....do..........	..do..	Do.
Continental Eagle Corp.								
Sixteen D:								
66 inch.............	16	1,214	5	4-7/16	3/32	0.010 inch, spring loaded	1/16	Do.
94 inch.............	16	1,214	5	4-7/16	3/32	.....do..........	1/16	Do.
94 inch:								
Constellation........	16	1,214	5	4-7/16	3/32	.....do..........	..do..	Do.
Super Constellation..	16	1,214	5	4-7/16	3/32	.....do..........	..do..	Do.
24-D Golden Eagle..... (101 inch)	24	908	8	4-7/16	3/32	.....do..........	..do..	Do.
Moss Constellation.... (62-1/2 inch)	16	1,000–1,200	5	4-1/2	1/16	.....do..........	..do..	Do.
Moss Super Constellation (62-1/2 inch)	16	1,000–1,200	5	4-1/2	1/16	.....do..........	..do..	Do.
Lummus Corporation								
Model 66.............	16	800–1,200[2]	6	4	1/16	0.005 inch, floating spring loaded	1/32	Brush, 15-inch diameter
Model 86.............	16	800–1,200[2]	6	5-3/8	1/16	.....do..........	..do..	Do.
Model 108............	16	800–1,200[2]	6	5-3/8	1/16	.....do..........	..do..	Do.

do = ditto.
[1]All makes of machinery have a 1/16-inch feed-roller-to-saw setting.
[2]A speed of 1,000 rpm is most common.

Table 5–7.
Power requirements and recommended installation of saw lint cleaners

Make	Condenser diameter (inches)	Axial-flow fan		Horsepower	Recommended installation	Capacity (bales/hr)
		Horsepower	Type and size[1]			
Consolidated HGM Corp.						
Multisaw Super 86 inch	50	15; 25	V.A., 29"; V.A., 36"	5, feedworks; 40, stripped cotton; 50, picked cotton.	Single unit or battery unit or as a second stage.	8–10
Super 66 inch	50	10–15	C.A., 42"	.........25........	Behind each gin stand, single and tandem, or battery units.	5–7
Super 86 inch	50	15; 25	V.A., 29"; V.A., 36"	5, feedworks; 30, no fan; 40, with fan.	........do...........	8–10
Continental Eagle Corp.						
Sixteen D:						
66 inch	24	5 per unit	V.A., 26"	........15........	Unit behind each gin stand, single and tandem.	8
94 inch	24	10 or 20	V.A., 26", single or tandem.	........30........	........do...........	12
94 inch:						
Constellation	50	5–20	V.A., 42"	........30........	Battery unit or tandem.	12
Super Constel	50	Two 5–20	V.A., 42"	.....Two 30's.....	Battery unit or tandem, split stream.	24
24 D Golden Eagle .... (101 inch)	24	20	V.A., 26"	........40........	Unit behind each gin stand, single and tandem.	16
Moss Constellation.... (62.5 inch)	50	5–10	C.A., 42"	........25........	Battery unit or tandem.	7–8
Moss Super Constel ... (62.5 inch)	50	5–10	C.A., 42", 2 per battery.	.....Two 25's.....	Battery unit or tandem, split stream.	14–16

Table 5–7.
Continued

Make	Condenser diameter (inches)	Axial-flow fan		Horsepower	Recommended installation	Capacity (bales/hr)
		Horsepower	Type and size[1]			
Lummus Corporation						
Model 66	24	3–20 as required.	V.A., 18", per machine; V.A., 24", per two machines.	........15........	Behind each gin stand, single and tandem or split stream.	4–6 per machine, 2–3 when split.
Model 66	24	...do...	....do......	......15–20.......	Battery units, single and split stream.	4–6 per machine.
Model 86	30	10–30 as required.	V.A., 24", per single or double machine.	30 per machine	Behind each gin stand, single and tandem, or split stream.	6–10 per machine, 3 to 4-1/2 when split.
Model 86	30	...do...	....do......	.......do.........	Battery units, single and split stream.	6–10 per machine.
Model 108	30	15–30 as required.	V.A., 24", per machine; V.A., 36", per two machines.	40 per machine	Behind each gin stand, single and tandem, or split stream.	8–14 per machine, 4–7 when split.
Model 108	30	...do...	.....do......	.......do.........	Battery units, single and split stream.	8–14 per machine.

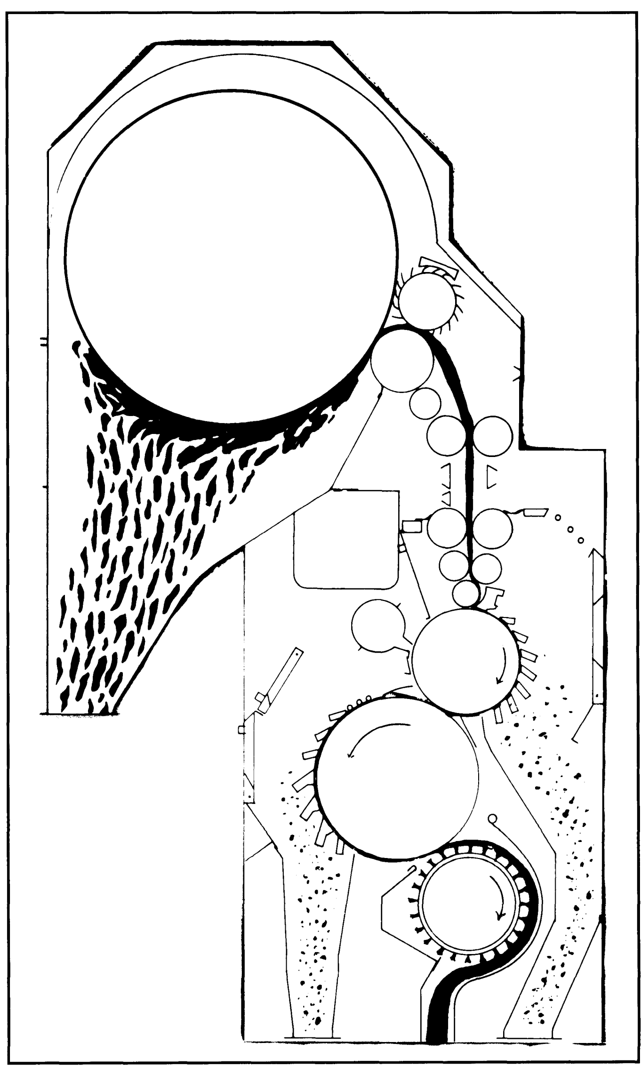
do = ditto.
[1]Manufacturer's description is shown (V.A. = vane axial, C.A. = clean air).

ance between the gin stand, the condenser, the duct fan, and lint flue. Axial or vane-axial fans, often referred to as clean-air fans, are usually used to discharge air from lint cleaner condensers. If high-efficiency cyclones are required for air pollution control, centrifugal fans should be used to overcome the additional static pressure.

Multisaw Lint Cleaner

The multisaw lint cleaner utilizes two types of traditional saw cylinders with grid bars within the same machine (fig. 5–46). The first stage of cleaning is performed by a controlled-batt saw cleaner. Cleaned lint from the first saw cylinder is doffed directly onto the second saw cylinder for a second stage of cleaning. Three card-type bars assist in spreading and attaching the lint uniformly over the second saw. After the second stage of lint cleaning, the cotton is doffed by a brush (Sutton and Horn 1986, Consolidated HGM Corporation 1987).

Figure 5–46. Multisaw lint cleaner (courtesy of Consolidated Cotton Gin Co., Inc.)



Multiple Lint Cleaning

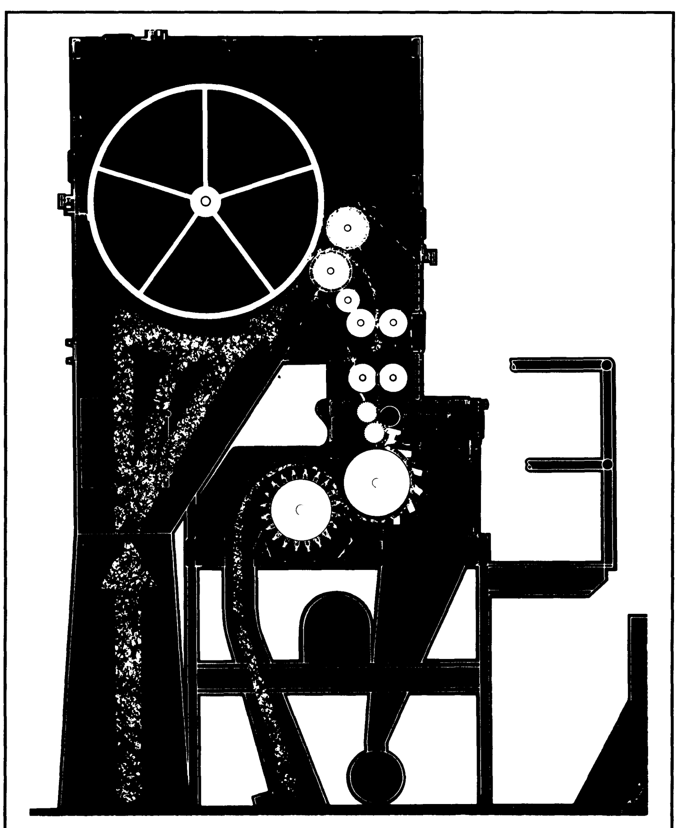
Lint cleaners are referred to as either unit or battery (or bulk) cleaners, depending on whether they process lint from one or more gin stands. The unit cleaner (figs. 5–42, 5–44, and 5–45) is located behind a gin stand and receives lint from only that stand. A battery cleaner (fig. 5–47) receives lint from two or more gin stands. Two lint cleaners, either unit or battery, can be placed in series so that the same lint passes through both of them, resulting in what is variously called tandem, dual, or double lint cleaning (fig. 5–48). The number of stages of saw cleaning refers to the number of saws over which the fibers pass.

In some gin plants, the battery cleaners are installed back-to-back with a common lint flue (fig. 5–49). When the cleaners are installed back-to-back, the lint from all the gin stands is divided ("split stream"), and each saw receives only half of the cotton.

Feed Rate

Lint fed to the cleaning machinery at too high of a rate will result in decreased cleaning efficiency and perhaps lower bale values. For efficient cleaning, feed rates should average about 1.0 bale/hr/ft of saw-cylinder length. Many gins, however, can handle up to 1.5 bales/hr/ft of saw with no

Figure 5–47. Bulk saw lint cleaner (Moss Constellation lint cleaner, courtesy of Continental Eagle Corporation)



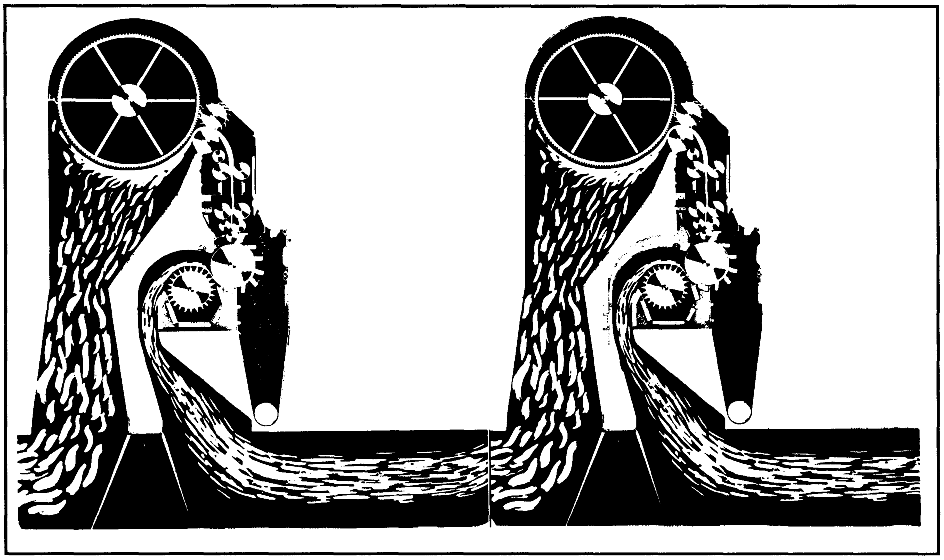


Figure 5–48. Unit saw lint cleaners in series (Super 66 or 86 lint cleaners, courtesy of Consolidated Cotton Gin Co., Inc.)

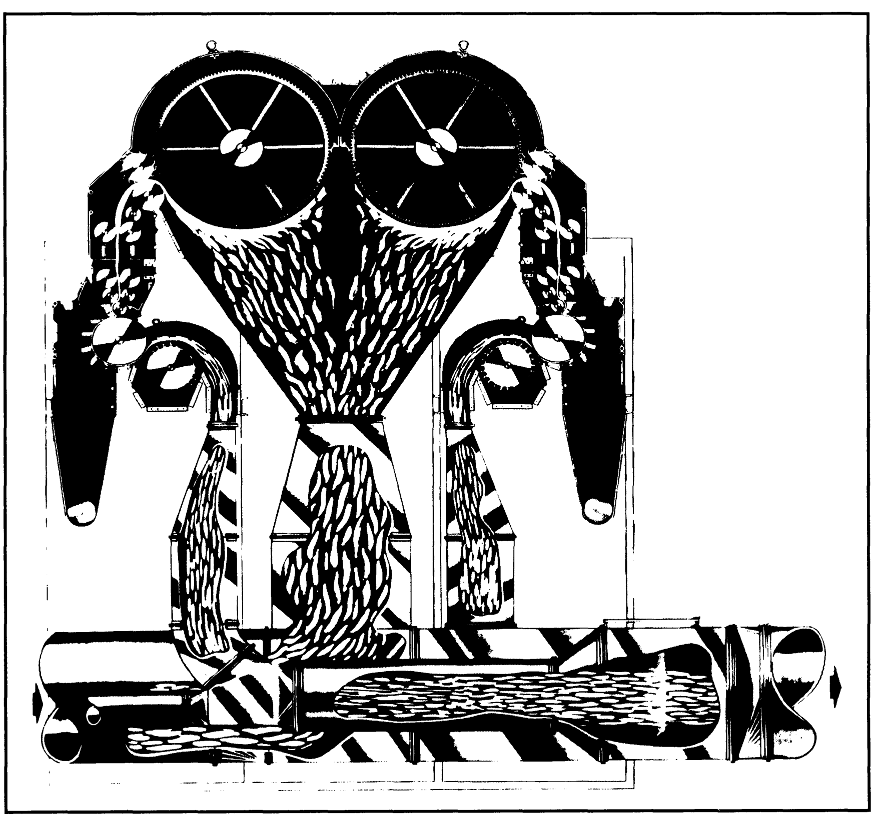


Figure 5–49. Battery (bulk), split-stream saw lint cleaners (Moss Super Constellation lint cleaner, courtesy of Continental Eagle Corporation)

noticeable problem; this rate corresponds to about 7 bales/hr for a 66-inch model lint cleaner (54-inch saw cylinder) and about 10 bales/hr for an 86-inch model cleaner (82-inch saw cylinder). The unit lint cleaner in figure 5-45 uses a 24-inch diameter saw (101-inch saw cylinder) and achieves 1.9 bales/hr/ft of saw length. This machine uses the same design principles as other controlled-batt machines but allows a larger area for cleaning.

Some gins have two lint cleaners behind the gin stand and have valves that allow choosing modes of operation. The entire output of the gin stand can flow through first one lint cleaner and then the other, or the lint can be split so that half of the total output flows through each of the lint cleaners. If the lint is split, the speed of the condenser and feed works should be slowed; thus, the combing ratio of each lint cleaner will generally be doubled (Griffin et al. 1970, Lummus Industries, Inc., 1984).

Feed Works

The auxiliary feed rollers, the fluted main feed roller, and the feed plate are collectively called “feed works” because they feed the cotton to the saw cylinder. Cotton passes through the narrow gap between the feed roller and the feed plate and then reverses direction around the toe of the feed bar to move onto the saw cylinder. The fluted feed roller is under spring tension, exerting pressure toward the face of the feed bar and holding the batt while it is combed and fed to the saw.

The setting of the feed plate with respect to the saw is extremely important for proper operation of the machinery and efficient cleaning. Special clearance gauges are available to facilitate this important adjustment. Another critical setting is the location and clearance of the fluted roller relative to the feed bar. If the fluted roller is too far away or if it comes closest to the feed bar at a point that is too far from the toe of the feed bar, the roller and bar will not grip the cotton properly and will allow large patches of cotton to be pulled from the batt by the saw. This cotton will ride the top of the sawteeth, and some of it will be stripped off by the grid bars and thrown into the motes. All clearances for the feed works should be set as specified by the manufacturer of the lint cleaner.

Some manufacturers offer variable speed controls for feed works of lint cleaners to make them more adaptable to variations in feed rate. These controls enable the operator to avoid breakage or thinning of the batt and, thus, excessive “stuffing” due to an uneven feed.

Saw Cylinder

The saw cylinder is covered with toothed wire wound in a spiral from one end to the other. Usually there are eight spiral wraps of wire per inch of saw cylinder length. There are normally 5–6 teeth/linear inch of wire, creating a cylinder population of about 45 teeth/in^2.

Saw teeth must be needle sharp to properly comb fibers from the batt. Dull teeth pull wads from the batt, thereby decreasing the cleaning efficiency while increasing cotton loss through the grid bars. When the teeth become dull, cylinders should be replaced or rewound with new wire. The ginner should be careful to ensure that the replacement cylinder meets original equipment specifications. Factors such as the cylinder diameter, the tooth size, the number of teeth per inch, the number of turns per inch, and the shape of the tooth should be maintained.

Combing Ratio and Saw Speed

In saw lint cleaners the uniformity and thickness of the batt and the manner in which it is delivered to the sawteeth are important in the effective operation of the cleaner. These conditions are controlled to some extent by the machine design but, in some cases, may be modified by the ginner by regulating the ginning rate, combing ratio (the ratio of the rim speed of the saws to the rim speed of the fluted or final feed roller), or saw speed of the lint cleaner.

Increasing the combing ratio and saw speed usually increases the cleaning efficiency of the cleaner but may adversely affect the spinning qualities of the cotton. Most lint cleaners normally operate within a combing ratio of about 16–28 and at saw-cylinder speeds of 800–1,200 rpm (saw tip speed of 3,350–5,700 ft/min). These settings should not be changed without consulting the manufacturer. Higher-than-normal ratios and saw speeds will sometimes result in high fiber breakage and high nep counts, while lower ratios and speeds considerably decrease cleaning efficiency (Mangialardi 1970, Baker 1978).

Grid Bars and Air Wash

The number of grid bars in a modern lint cleaner may vary from four to eight depending on the model used. Clearance gauges are used to set the grid bars with respect to the saw cylinder. The nose of the grid bar is set 1/32–1/16 inch from the saw. If the nose or leading edge of the grid bar is farther away from the saw than the body of the bar, a wedge will form and force sticks into the saw. The leading edges of the grid bars should have the same clearance all the way across the machine with reference to the saw. A keen edge should also be maintained on the nose of the grid bar. Worn bars will waste substantially more fiber than new, sharp bars, decreasing lint turnout (Baker and Brashears 1988).

Cotton ginning plants use grid-bar air wash to improve lint cleaner efficiency, pick up and remove waste, and reduce air pollution within the gin plant. Air movement across the grid bar area should average 350–400 ft^3/min/ft of grid-bar length. Thus, the air movement would total about 2,700 ft^3/min for an 86-inch model lint cleaner (Lummus Industries, Inc., 1984).

Lint Cleaner Waste

The amount of material removed by lint cleaners varies with harvesting practices and grades of cotton being ginned. When multiple stages of saw lint cleaners are used, the first cleaner removes the most weight. Typical quantities of waste removed by one, two, and three stages of lint cleaning, respectively, are 22, 30, and 36 lb for spindle-picked cotton and 31, 41, and 45 lb for machine-stripped cotton (Baker 1972, Mangialardi 1972, Mangialardi 1988).

Lint cleaner waste from relatively clean cottons contains a greater percentage of lint than that from trashier cottons. Nonlint content of the lint cleaner waste for one, two, and three stages of lint cleaning, respectively, averages about 75, 70, and 67 percent. This material is composed of motes, leaf particles, grass, stems, bark, bracts, and seedcoat fragments.

The sale of reclaimed gin waste may provide income for cotton gin owners. The bedding, automotive, and furniture industries use large quantities of cotton batting composed of about 60 percent linters (short fibers left on the cottonseed at the gin) and 40 percent cotton waste. It is usually desirable to remove sticks and other large trash particles with mote cleaners to make the waste more marketable. If waste materials are removed, the increased value of the cotton per pound should more than compensate for the weight loss attributed to cleaning (Holder 1967).

Doffing Brush

The brush should be set so that the ends of the bristles just touch the points of the saw teeth. If the bristles are extended into the saw, undue wear on the bristles will occur because the saw, which is spirally wrapped, works like an oscillating saw and will shear the bristles on the brush. Proper adjustment of the brush will therefore prolong its life and ensure efficient doffing (Continental Eagle Corporation 1969).

At the rear of the brush is an opening to the brush chamber. This opening admits the amount of air required by the brush and reduces the siphoning of trash between the saw and division board.

A frequent problem, back pressure on the doffing brush, can be caused by using too small a discharge line from the machine or by having inadequate pull from the down-line condenser. The back pressure causes excessive wear of the doffing brush.

When replacing brushes, consideration should be given to using solid-face doffing brushes. At a given speed the solid-face brush produces more air and much less noise than a paddle brush (see "Noise in Cotton Gins" in section 11). Because of the different air handling characteristics of the solid-face brush, adjustment may be necessary in the brush speed and/or the speed of the fan conveying lint between the lint cleaners.

Lint Retrievers

A lint-cotton retriever is used in some gins to reduce lint losses. The apparatus recovers spinnable fibers from the foreign matter and fibers extracted by the lint cleaners and blends the recovered fibers back into the cotton stream ahead of the lint cleaners (fig. 5–50). The amount of fibers recovered depends on the number of lint cleaners used and on the condition of the cotton. In a typical two-lint-cleaner system, a retriever unit increases the bale weight by 10–12 lb. Although properly operated lint retrievers do not significantly affect cotton quality, some cotton merchants and spinning mills disapprove of using the machines. Therefore, the use of a lint retriever at a gin will depend on the relationship between the grower and the buyer of the cotton (Baker et al. 1983, Griffin and Mangialardi 1983, Mangialardi and Cocke 1984).

Cotton Quality

Perhaps the best index of cotton quality is the performance of the fibers during spinning at the mill. Increasing the number of saw lint cleaners at the gin decreases the manufacturing waste during spinning but often has the adverse effects of increasing neps in the card web and lowering the yarn strength and appearance (fig. 5–51). These changes are also often accompanied by an increase in ends down during spinning. While lint cleaning at the gin reduces yarn quality and spinning performance, the loss in quality due to a single stage of lint cleaning is relatively modest compared with the benefit gained from the amount of cleaning accomplished. Although additional stages of lint cleaning further clean fiber, they do so at a slower rate than they increase fiber damage (Baker and Bragg 1988). Consequently, from a spinning standpoint the use of more than two saw lint cleaners in series is discouraged.

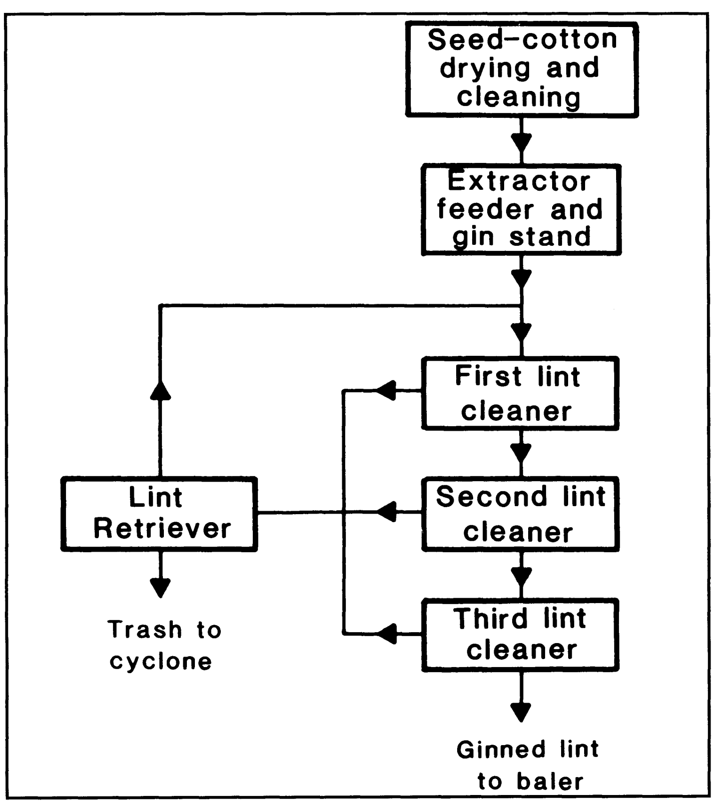


Figure 5–50. Flow chart showing the lint-retriever recycling system

Bale Value

Lint cleaning generally improves the grade classification of the lint. However, the extent of grade improvement decreases with each succeeding cleaning. In addition, lint cleaners blend Light-Spotted cottons so that some of these pass into the White grades. Lint cleaners can also decrease the number of bales that are reduced in grade because of grass and bark content. But they also reduce bale weights and may decrease staple length, thus affecting bale value (fig. 5–52). In some cases the net effect of multiple stage lint cleaning is loss in bale value.

When price spreads between grades are small, the grower can most often maximize bale value by using one saw lint cleaner on early-season clean cottons and two stages of lint cleaning on late-season, more trashy, or Light-Spotted cottons. This holds for both spindle-harvested and machine-stripped cottons (Looney et al. 1963, Baker 1972, Mangialardi 1972). Smooth-leaf-variety cottons will generally require one less lint cleaner than hairy-leaf varieties for maximum market value of the bale (Mangialardi 1988).

Figure 5–51. Effect of saw lint cleaners on nep count, yarn strength, and appearance

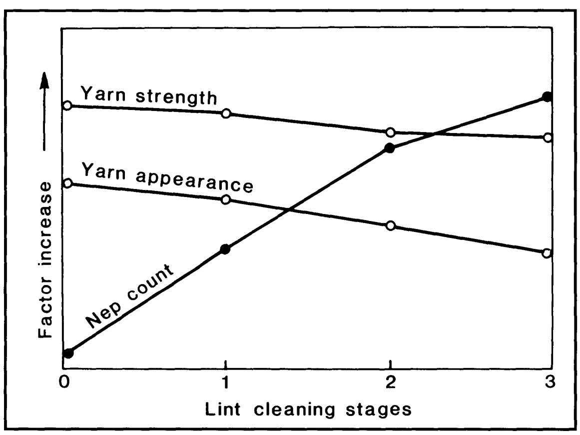
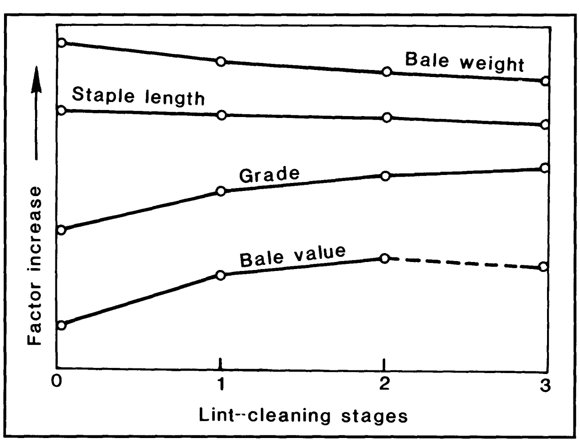


Figure 5–52. Effect of lint cleaners on classer's lint grade and staple length and on bale weight and value



Maintenance and Operation

The ginner and crew must know their machines—how they work and the required operating settings and speeds. For best performance and service, the recommendations of the manufacturer as provided in service manuals and parts catalogs should be carefully followed. These sources provide maintenance procedures and troubleshooting guides, close adherence to which will minimize the time required to keep machines in normal operation. When in doubt regarding appropriate action, the ginner should contact the manufacturer's nearest office.

Maintenance of the condenser will require occasional replacement of the rubber flashing around the drum and across doffing rollers. The feed roller rubber flashing will wear and should be replaced to prevent air leakage.

Regular maintenance should involve adjusting the tension on V-belts and chain drives, including the hidden V-belt drive to the vane-axial fan in the condenser flue. When replacing badly worn chains, it is good policy to also replace the sprockets on which the chains operate because the worn teeth on the sprockets will not mate well with the new chain. If the sprockets are not replaced, adjusting the alignment may stop new chains from slipping. Regular checks should include looking for loosened set screws, bolts, and jam nuts. Before any bolt that holds a clearance is tightened, the clearance should be gauged and set to comply with recommended dimensions.

Most ball bearings are the sealed type and are packed with high-temperature grease; they should never need further lubrication.

To start the lint cleaning system, first turn on the trash fan, then the lint cleaner and the condenser, followed by the vane-axial or centrifugal fan in the condenser flue. Shut down the system in reverse order, but first stop the flow of cotton.

The sequence of the emergency stopping procedure depends entirely on the position of the operator. If the operator is nearer to the machine than he or she is to the control console, the belt release should be quickly pulled before the electrical "stop" button is pushed. If the stop button is pushed first, the belt release should also be quickly pulled while the saw cylinder is still turning.

Any obstruction that will tag cotton should be removed or smoothed. Flow-through air cleaner installations should be inspected each day for tags in the lint flue between the gin stand and the lint cleaner.

Periodic inspection of saw cylinders is necessary. Embedded trash between teeth should be removed with a stiff brush (but only when the machine is completely stopped). Vane-axial fans should be kept free of lint tags, which reduce fan efficiency and can cause friction fires.

About one-half of employee accidents at cotton gins involve lint cleaners (McManus 1986). Section 11 provides general safety information for preventing accidents associated with these machines.

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Packaging Lint Cotton

W.S. Anthony, D.W. Van Doorn, and Douglas Herber

Bale packaging is the final step in processing cotton at the gin. The packaging system consists of a battery condenser, lint slide, lint feeder, tramper, bale press, and bale tying mechanism. This system may be supplemented with systems for bale conveying, weighing, and wrapping. The bale press consists of a frame, one or more hydraulic rams, and a hydraulic power system. Tying subsystems may be entirely manual, semiautomated, or fully automated.

Bale presses are described primarily by the density of the bale that they produce, such as low density (flat or modified flat) or universal density (gin or compress). Other descriptions include up-packing, down-packing, fixed box (fig. 5–53), and doorless (fig. 5–54). Regardless of description, they all package lint cotton so that it can be handled in trade channels and at the textile mills (Anthony and McCaskill 1977).

Battery Condenser

Condensers have a slow-turning, screened or perforated metal-covered drum on which the ginned lint forms a batt. The batt is discharged between doffing rollers to the lint slide. Conveying air supplied by a vane-axial or high-volume

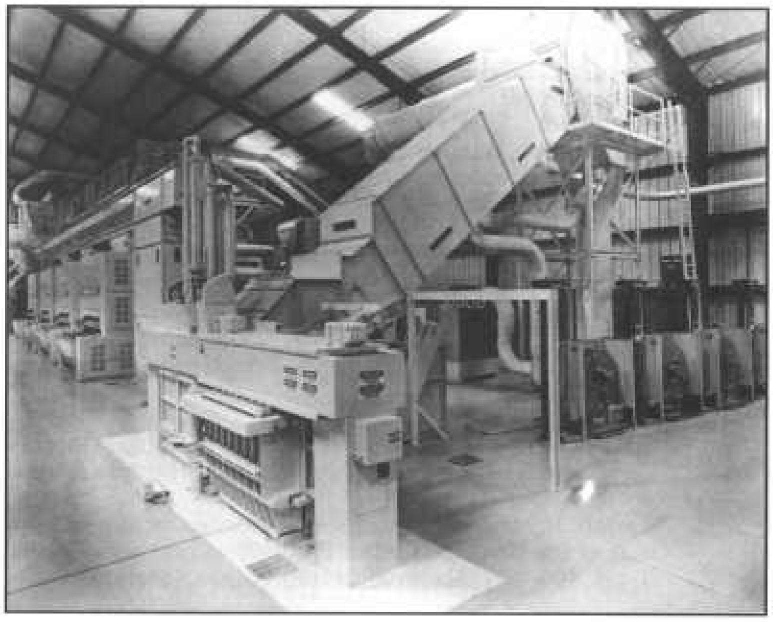


Figure 5-53. Fixed-box press with automatic strapping

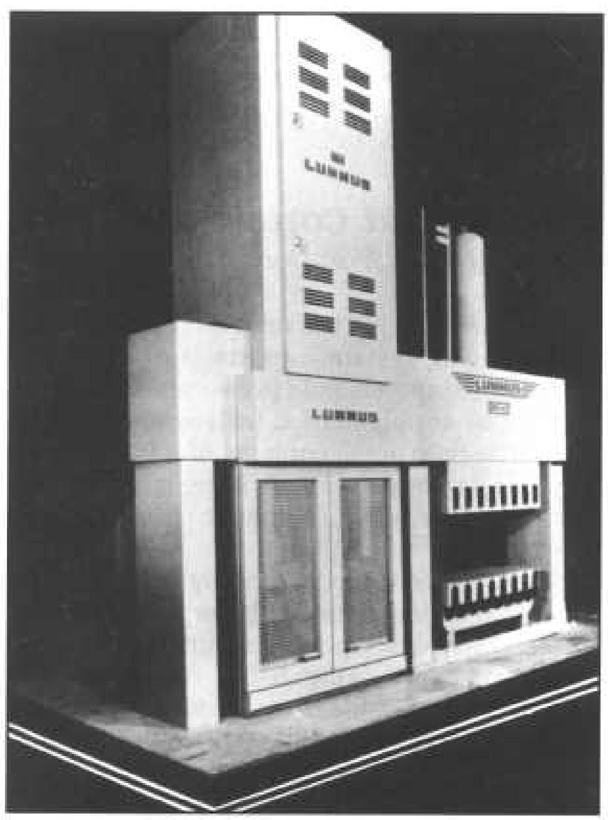


Figure 5-54. Doorless press

centrifugal fan passes through the screen on the drum and is usually discharged out one end of the drum through an air duct. The discharged air then goes to dust abatement equipment and then into the atmosphere.

The speed of the condenser drum should be adjusted to the capacity of the gin so that a smooth, solid batt is formed. If the drum runs too fast, breaks will occur in the batt; if too slow, the batt will be thick, causing high static pressure loss, backlash in a lint cleaner, and possible chokage. The recommended condenser drum peripheral speed is 6–15 rpm.

Uneven formation of the lint batt in the condenser is one of the primary causes of big-ended bales (Anthony 1982a). Big-ended bales are formed when more lint is deposited at one end of the press box than at the other. During the pressing operation, the increased resistance at one end of the bale forces the follow block into an inclined position, thus forming wedge-shaped bales. Fixed-length ties prevent the bale from having an uneven shape when it is released from the press. Uneven lint distribution can be identified from observing the size of the connection on wire ties—the more cotton under the tie, the more force on the tie, and the smaller the “knot” (Anthony 1975). Sometimes condensers will produce batts that are heavier in the center. This will not only put excessive stress on the center ties but also can result in wedge-shaped bales from top to bottom because the low-density cotton at the ends of the bales opposite the compression platen tends to flow laterally when released from the press box.

The danger of tramper breakage, damage to ram seals, and press distortion is increased with uneven bales. In addition, subsequent recompression of modified flat bales to universal density will cause fiber shearing between the areas with widely different densities.

Deviations in the airflow to the condenser will affect the lint flow. Lint flues that are bent or dented can affect the flow of air so that lint will not batt uniformly. Sheet metal deflectors can be used in lint flues to provide uniform distribution of the lint on the condenser drum so that the formation of big-ended bales is prevented. Foreign matter, lint tags, rivet heads, rust, or protrusions, can often cause deflection of the air current, resulting in uneven batts on the screen of the condenser.

Condensers in poor operating condition, flashings in bad condition, and nonuniform drum resistance due to accumulations on the screen may cause more cotton and air to be deflected to one end of the drum and thus may produce big-ended bales. Daily inspection of the condenser and its lint ducts and discharge ducts will reduce the number of poorly shaped bales.

Battery condensers that discharge the conveying air from only one side are sensitive to the volume of airflow. Excess airflow will cause the batt to form on the drum nearest the air discharge and cause a big-ended bale. This problem can usually be corrected by reducing the air volume; however, installation of a larger condenser may be necessary. Use of a double-manifold condenser, which is similar to a lint cleaner condenser, would be another way to correct the problem of big-ended bales and would help produce a more uniform batt of cotton for the press. The upturned elbow in the lint duct nearest the battery condenser should be rectangular (fig. 5–55), as should the remainder of the duct leading to the condenser. The back of the rectangular elbow should be inclined at a 15° angle to allow cotton to impact the elbow and be directed upward under the control of the air flow to the condenser drum. The condenser, its discharge duct and fan, and the lint ducts should be sized to properly handle the air volume discharged by the lint cleaners or gin stands that are to supply air to the system. The machinery manufacturers can give air volume ratings for each item of equipment in the system for proper system design.

Lint Slide

The lint slide is a sheet metal trough (approximately 54 inches wide) that connects the battery condenser to the lint feeder on the tramper. It is installed at an angle of 33°–45° to ensure movement of the lint without rolling the batt. The length of the lint slide is based on the capacity of the ginning system and the time required to turn the press between bales. The information on the right can be used for selecting lint slide lengths based on ginning capacity.

Maximum ginning capacity (bales/hr)	Lint slide length (ft)
12	12
18	15
24	18
30	21
36	24
42	27
48	30
54	33
60	36

Lint Feeder

The lint feeder is a device for moving lint from the lint slide into the charging box of the press. There are three basic types of feeders: (1) the revolving paddle kicker, (2) the belt feed used in conjunction with the kicker, and (3) the lint pusher. All of these devices should deposit lint into the charging box with a fast but gentle action, without breaking up the batt as it is received from the condenser. A smoother lint sample will result if this can be accomplished.

Rolling bales are caused primarily by poor distribution of the lint from front to back in the charging box under the tramper as the tramper makes each downward stroke. This can be caused by faulty action of the charging device (Watson and Stedronsky 1943) or an inadequate supply of lint to the press for an extended period of time. Another cause of rolling bales is faulty action of the press "dogs" on one side of the press box. If the dogs do not reliably hold down the lint uniformly on both sides of the box, the lint density from the front to the back of the box will be ununiform and a rolling bale will be produced.

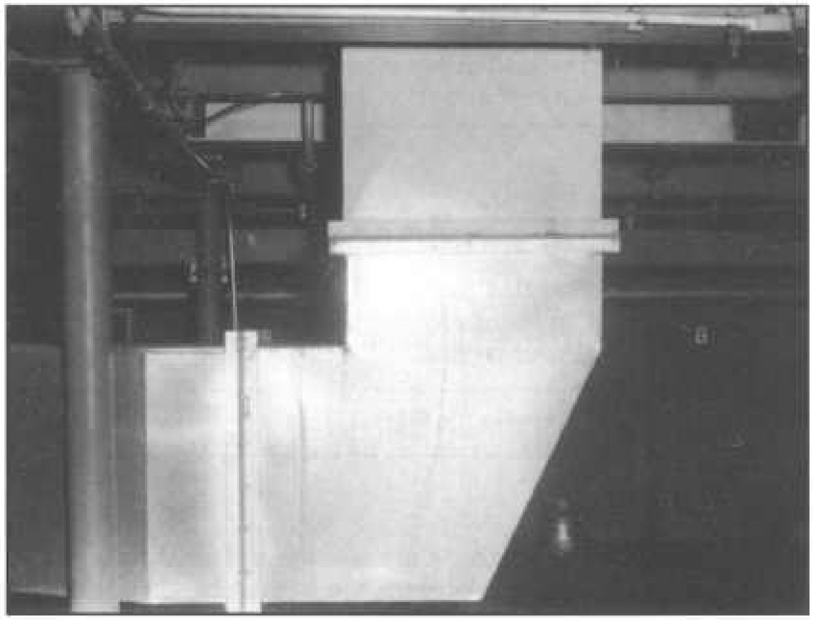


Figure 5-55. Typical rectangular elbow and duct near the battery condenser. The back of the elbow is inclined at 15° from vertical to improve lint distribution at the lint slide.

Tramper

The purpose of the tramper is to pack the lint into the press box under the restraining dogs near the top end of the press box. Mechanical and hydraulic trampers are available. Regardless of type, care should be taken to prevent contamination of lint beneath the tramper by hydraulic fluid or grease from the tramper mechanism. Motors that have 10–15 hp and that are equipped with a fail-safe brake are usually used on mechanical trampers. Motors used on hydraulic trampers vary from 25–75 hp.

A rate of about 10 tramper strokes/min is recommended for gins with capacities of 12–15 bales/hr. For higher capacity gin plants, both the tramper stroke length and speed are increased to increase the size of the charges as well as the number of charges per minute. The lint feeder and tramper should have a capacity greater than the gin plant capacity to be able to accommodate the extra lint accumulated in the lint slide during turning of the press boxes. If the tramper gets behind when processing the cotton, the tramper should be able to catch up with the lint flow from the condenser well before the press box is filled. This will allow the bale weight control system to produce uniform bale weights. Varying bale weights not only have a very detrimental effect on the energy consumption of the press and on the bale tie forces but also cause serious problems at the textile mills (Jones 1980).

Bale Press

There are four types of gin presses; each type is named according to the bale it produces—flat, modified flat (bales to be sent for recompression to become compress universal density bales), gin standard, and gin universal. The bales

Table 5–8.
Types and dimensions of the four most common bales produced at cotton gins

Bale type	Bale dimensions (inches) Length	Width[1]	Thickness[1]
Flat	55	28	36–48
Modified flat	55	25	36–48
Gin standard	55	20–21	30–36
Gin universal	55	20–21	26–30

[1]Measured at the bale tie.

produced by these presses are different in size (table 5–8) and density (table 5–9). Flat-bale presses are being phased out in favor of modified flat-bale presses because bales produced by the latter can be converted to universal bales (55 by 26–28 by 20–21 inches) without applying side pressure to the bale. Bales from a flat-bale press (27 by 54 inches) can easily be converted to modified flat press bales (24 by 54 inches) (National Cotton Council 1972). The long-range goal is to have only one type of bale—gin universal density. About 90 percent of the bales produced at gins in the United States in 1992 were gin universal density.

Hydraulics

The hydraulic requirement to press lint cotton depends on the moisture content of the lint, the density to which the lint is to be pressed at final platen separation, and, to a lesser extent, the distribution of lint in the press box (Anthony and McCaskill 1973). Typical densities encountered in the press box when pressing flat, modified flat, and standard or universal bales are shown in table 5–10.

The force required to compress lint cotton to given densities at various moisture contents may be predicted from the equation

$$\log_{10}F = 2.0929 - 0.0313m + 2.4469 \log_{10}P,$$

where

F = compressive force (lb),
m = lint moisture content (wet basis) (percent), and
P = density (lb/ft^3).

Table 5-9.
Typical densities of bales from flat,[1] modified flat,[2] and gin universal[3] bale presses

Bale dimensions[4] (inches)	Volume (ft^3)	Density (lb/ft^3) at bale weight (lb) of: 460	480	500	520	540	560
Flat bale							
55x28x36	32.1	14.3	15.0	15.6	16.2	16.8	17.5
55x28x38	33.9	13.6	14.2	14.8	15.4	15.9	16.5
55x28x40	35.6	12.9	13.5	14.0	14.6	15.1	15.7
55x28x42	37.4	12.3	12.8	13.4	13.9	14.4	15.0
55x28x44	39.2	11.7	12.2	12.8	13.3	13.8	14.3
55x28x46	41.0	11.2	11.7	12.2	12.7	13.2	13.7
55x28x48	42.8	10.8	11.2	11.7	12.2	12.6	13.1
Modified flat bale							
55x25x36	28.6	16.1	16.8	17.5	18.2	18.9	19.1
55x25x38	30.2	15.2	15.9	16.5	17.2	17.9	18.5
55x25x40	31.8	14.5	15.1	15.7	16.3	17.0	17.6
55x25x42	33.4	13.8	14.4	15.0	15.6	16.2	16.8
55x25x44	35.0	13.1	13.7	14.3	14.9	15.4	16.0
55x25x46	36.6	12.6	13.1	13.7	14.2	14.8	15.3
55x25x48	38.2	12.0	12.6	13.1	13.6	14.1	14.7
Universal bale							
55x20x26[5]	16.6	27.8	29.0	30.2	31.4	32.6	33.8
55x20x28[5]	17.8	25.8	26.9	28.1	29.2	30.3	31.4
55x20x30[6]	19.1	24.1	25.1	26.2	27.2	28.3	29.3
55x20x32[6]	20.4	22.6	23.6	24.5	25.5	26.5	27.5
55x20x34	21.6	21.3	22.2	23.1	24.0	24.9	25.9
55x20x36	22.9	20.1	20.9	21.8	22.7	23.6	24.4
55x21x26[5]	17.4	26.5	27.6	28.8	29.9	31.1	32.2
55x21x28[5]	18.7	24.6	25.6	26.7	27.8	28.9	29.9
55x21x30[6]	20.1	22.9	23.9	24.9	25.9	26.9	27.9
55x21x32[6]	21.4	21.5	22.4	23.4	24.3	25.2	26.2
55x21x34	22.7	20.2	21.1	22.0	22.9	23.8	24.6
55x21x36	24.1	19.1	19.9	20.8	21.6	22.4	23.3

[1]Press box area: 54 inches x 27 inches = 1,458 $inches^2$.
[2]Press box area: 54 inches x 24 inches = 1,296 $inches^2$.
[3]Press box area: 54 inches x 20 inches = 1,080 $inches^2$.
[4]Width and thickness measured at the bale tie.
[5]Suggested universal density bale size.
[6]Suggested standard density bale size.

Table 5–10.
Cotton densities measured in the press box when pressing flat,[1] modified flat,[2] and gin universal[3] bales

Platen separation (inches)	Density in press (lb/ft^3) at bale weight (lb) of:					
	460	480	500	520	540	560
Flat bale						
26	21.0	21.9	22.8	23.7	24.6	25.5
28	19.5	20.3	21.2	22.0	22.9	23.7
30	18.2	19.0	19.8	20.5	21.3	22.1
32	17.0	17.8	18.5	19.3	20.6	20.7
34	16.0	16.7	17.4	18.1	18.8	19.5
36	15.1	15.8	16.5	17.1	17.8	18.4
38	14.3	15.0	15.6	16.2	16.8	17.5
Modified flat bale						
26	23.6	24.6	25.6	26.7	27.7	28.7
28	21.9	22.9	23.8	24.8	25.7	26.7
30	20.4	21.3	22.2	23.1	24.0	24.9
32	19.2	20.0	20.8	21.7	22.5	23.3
34	18.0	18.8	19.6	20.4	21.2	22.0
36	17.0	17.8	18.5	19.3	20.0	20.7
38	16.1	16.8	17.5	18.2	18.9	19.6
Universal bale						
17	43.3	45.2	47.1	48.9	50.8	52.7
18	40.9	42.7	44.4	46.2	48.0	49.8
19	38.7	40.4	42.1	43.8	45.5	47.2
20	36.8	38.4	40.0	41.6	43.2	44.8
21	35.0	36.6	38.1	39.6	41.1	42.7
22	33.5	34.9	36.4	37.8	39.3	40.7
23	32.0	33.4	34.8	36.2	37.6	39.0
24	30.7	32.0	33.3	34.7	36.0	37.3
25	29.4	30.7	32.0	33.3	34.6	35.8
26	28.3	29.5	30.8	32.0	33.2	34.5
27	27.3	28.4	29.6	30.8	32.0	33.2
28	26.3	27.4	28.6	29.7	30.9	32.0

[1]Press box area of 1,458 inches^2.
[2]Press box area of 1,296 inches^2.
[3]Press box area of 1,080 inches^2.

The results of evaluating the prediction equation are shown in figure 5–56 for a density range of 10–45 lb/ft^3 and lint moisture contents of 3, 6, and 9 percent. Hydraulic systems should be able to perform under the most adverse conditions anticipated—they should be able to produce heavy bales that are low in moisture and small in size.

Bale Ties

After the bale is compressed to a given density or press platen separation, ties are applied around the circumference of the bale to restrain the lint within prescribed dimensions. Bale ties are normally either wire or flat, cold-rolled steel bands, or wire, and are placed at intervals along the length of the bale.

Usually, six, eight, or nine ties per bale are used. The weakest point of a bale tie is the connection. To increase the holding capacity of the tie, connections should be positioned near the top or bottom of the crown of the bale. The tie force is considerably less at that point, and the connection is protected because it tends to recess inside the fiber. Typical bale dimensions and tie lengths are shown in table 5–11. Final densities for gin universal density bales are shown in figure 5–57.

Flat and modified flat bales are normally packaged with six 10-gauge steel, interlocking, reusable wire ties having a minimum connected strength of

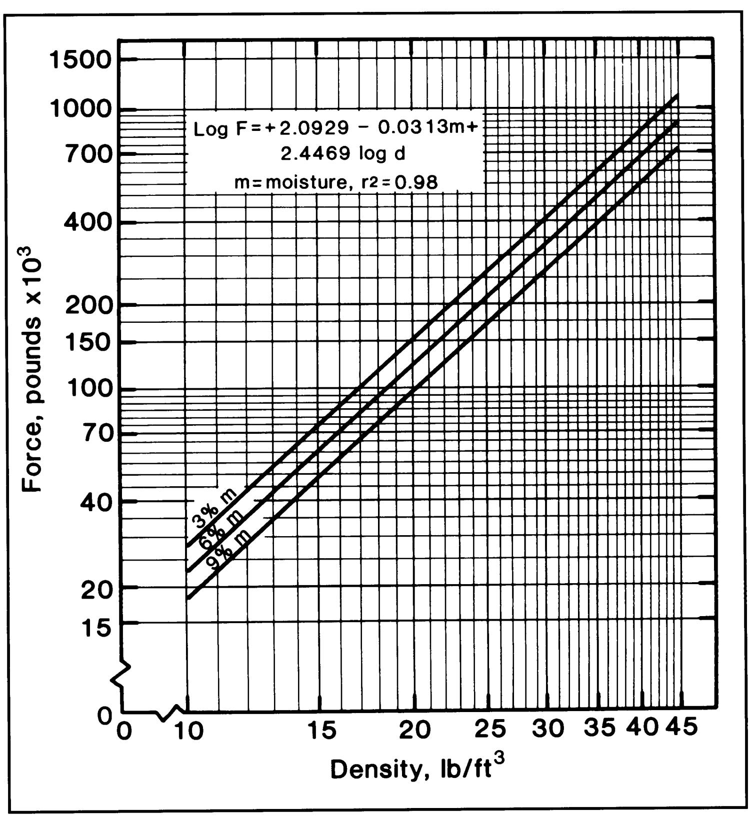


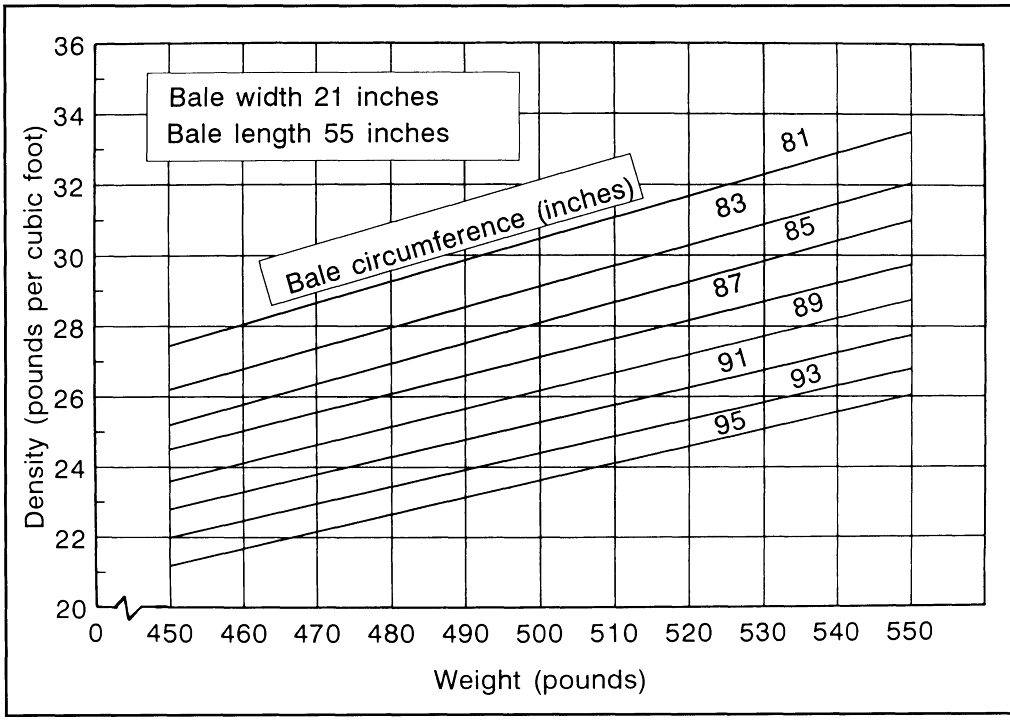
Figure 5–56. Predicted force to compress lint cotton at three moisture contents

Table 5–11.
Approximate bale dimensions and tie lengths (circumferences) for bales packaged in gin presses[1]

Press box dimensions[2] (inches)	Bale width (inches)	Bale thickness (inches)	Tie length (inches)
19 x 54	20	26	82.5
	20	28	86.5
	20	30	90.5
	20	32	94.5
	20	34	98.5
20 x 54	21	26	84.0
	21	28	88.0
	21	30	92.0
	21	32	96.0
	21	34	100.0
24 x 54	25	36	107.0
	25	38	111.0
	25	40	115.0
	25	42	119.0
	25	44	123.0
	25	46	127.0
	25	48	131.0
27 x 54	28	36	110.0
	28	38	114.0
	28	40	118.0
	28	42	122.0
	28	44	126.0
	28	46	130.0
	28	48	134.0

[1]Bale length and thickness measured at the ties.
[2]Dimensions are approximate.

Figure 5–57. Relationship of density, net weight, and circumference for gin universal density bales that are 21 inches wide and 55 inches long



1,850 lb. Gin standard density bales are normally packaged with eight steel bands having a connected strength of 2,700 lb or wire having a connected strength of 3,040 lb. Gin universal bales are normally packaged with eight flat, cold-rolled steel bands having a connected strength of 3,400 lb or wire having a connected strength of 3,040 lb. If the wire connections are placed on the top of the bale, connected strength requirements are 2,100 lb. Other configurations are approved and used in limited quantities. Information on currently approved bale tie materials can be obtained from the National Cotton Council, Memphis, TN.

Once the bale is released from the press, the lint cotton produces a resilient force on the bale ties. Excessive force exerted on the bale ties by the restrained cotton can cause the ties to break, and such breakage can cause contamination and handling problems. The force on each of the ties depends on its position on the bale (fig. 5–58) primarily because lint can be distributed nonuniformly within the bale. The bale tie with the greatest force exerted on it can have up to 15–20 percent of the total force exerted on all the ties of the bale. The force on the bale ties can also be affected by the platen separation to which a bale is pressed before applying the ties, the bale circumference at the tie after the bale is released from the press, and the lint moisture content. Figure 5–59 shows the effects of platen separation and bale circumference on maximum force per tie in 500-lb bales packaged at 5 percent lint moisture in a gin universal press. Maximum bale tie forces can be estimated as shown in the following example:

Figure 5-58. Nonuniform bale tie force distribution for one gin universal bale press

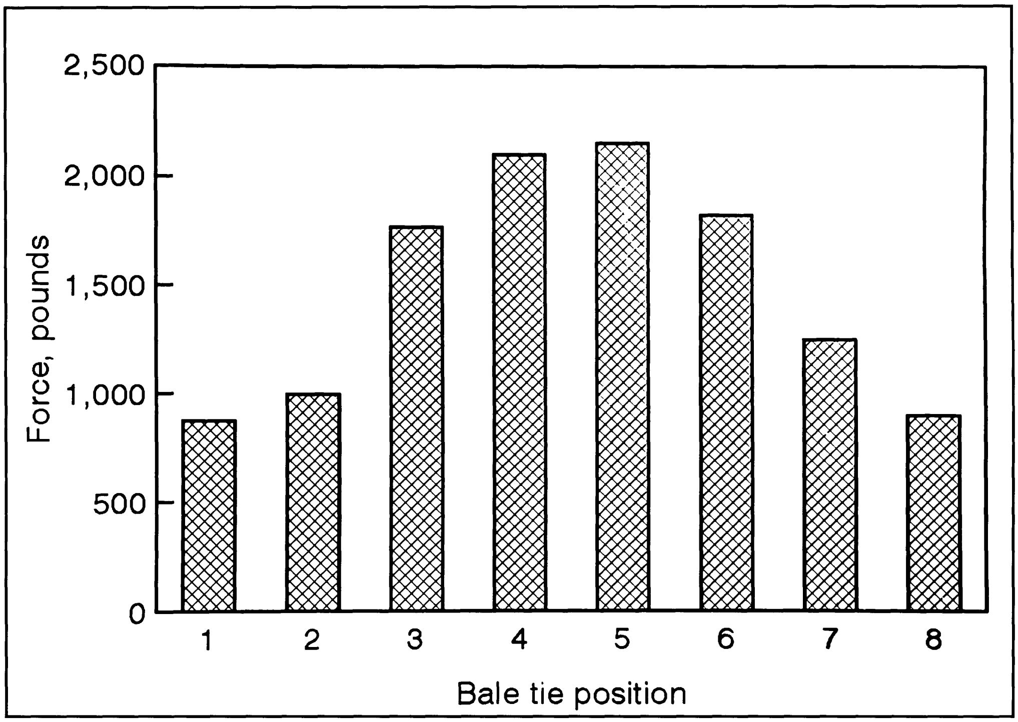
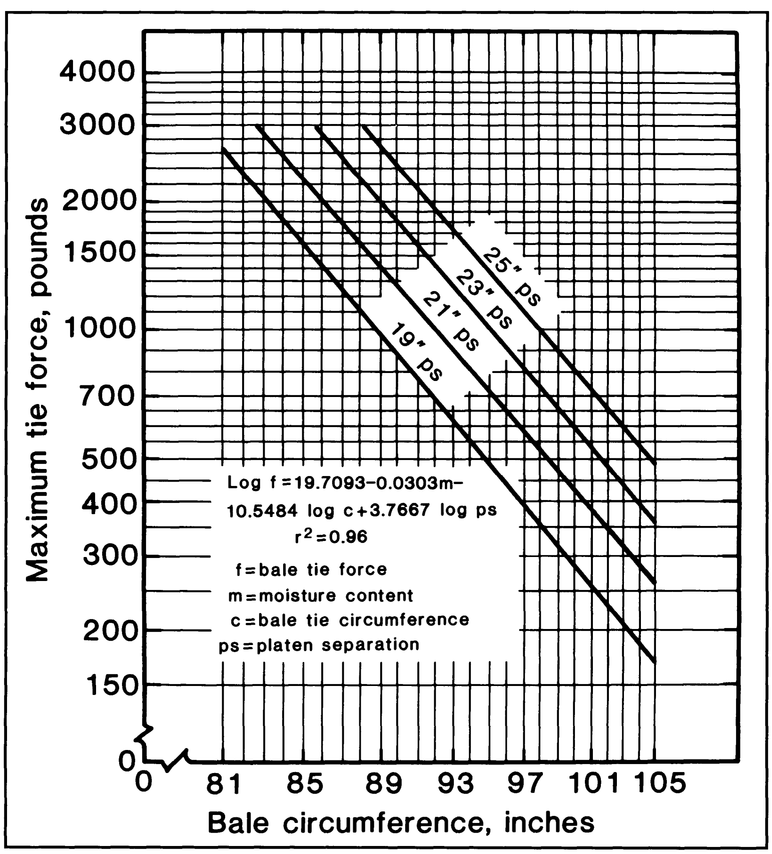


Figure 5-59. Average tie force (5 percent per tie) exerted by 500-lb bales of upland cotton at 5 percent lint moisture. The equation predicts the accumulated force on eight ties, and the graph depicts 15 percent of that force as an estimate of the maximum force on a single tie.



EXAMPLE: Determine the maximum tie force exerted on one of eight equally spaced bale ties on a 500-lb bale packaged at 5 percent lint moisture in a gin universal press. The bale circumference at the tie is 85 inches.

SOLUTION: Refer to figure 5–59 and note that the maximum tie force of 2,300 lb of force is exerted against the ties when the bale is compressed to a platen separation of 21 inches and 1,600 lb when the bale is compressed to 19 inches. Note that the equation in figure 5–59 calculates the total force exerted on all eight ties and that 15 percent of that force was used in the graph as an estimate of the maximum force on a single tie.

In the above example, note that a change in platen separation of only 2 inches without changing tie length resulted in a 30-percent reduction in maximum bale tie force. A 2-inch change in platen separation also increases the press compression force required from 550,000 lb to 750,000 lb. This 36-percent increase in required compression force would substantially increase press energy consumption. Therefore, the other means of reducing tie breakage described herein should be explored before resorting to reducing platen separation.

Variation in lint moisture and bale circumference (tie length) also has a pronounced effect on bale tie force. When a 500-lb bale at 5 percent lint moisture is compressed to a platen separation of 19 inches in a gin universal density press, a maximum tie force of 1,700 or 1,100 lb results, depending on whether restrained bale circumference is 84 or 88 inches, respectively (fig. 5–59). A 4-inch increase in bale circumference results in a 30-percent reduction in bale tie force but only a 2-inch change in bale thickness (table 5–11).

Changes in maximum bale tie force due to changes in bale circumference, moisture, and platen separation are given in table 5–12. Maximum bale tie force is about 15 percent less for cotton of 6 percent moisture than for cotton of 4 percent moisture. The maximum tie force on the ties of flat and modified flat bales vary in much the same manner as those on ties of gin universal bale presses; however, the forces involved on the former are lower (Anthony and McCaskill 1978).

Two other factors influencing bale tie force are compression density and restraint density. The resilient force of the cotton on the bale ties is directly related to the compression and restraint densities. The compression density is the density to which a bale is compressed (minimum platen separation) before it is released from the press. Compression density can be estimated by dividing the bale weight by the area of the press box. The restraint density is the final density of the bale after it has been removed from the press and may be determined by dividing the bale weight by the bale volume (length times width times thickness). Because calipers are required to measure the bale dimensions, it is more convenient to estimate the restraint density from the bale circumference (Anthony et al. 1980). Figure 5–57 demonstrates the relationship between restraint density, bale weight, and bale circumference for gin universal density bales.

Table 5–12.
Changes in estimated maximum bale tie forces as platen separation, bale circumference, and lint moisture change

Platen separation (inches)	Bale circumference (inches)	Moisture content (percent)	Estimated maximum force[1] (lb)	Force decrease (percent)
21	85	6	[2]2150	0
21	87	6	1680	22
20	85	6	1785	16
20	87	6	1400	35
19	85	6	1470	32
19	87	6	1150	47
21	85	4	[3]2460	0
21	87	4	1930	22
20	85	4	2050	17
20	87	4	1605	35
19	85	4	1692	31
19	87	4	1324	46

[1]Equal to 15 percent of the total force extended on all 8 ties.
[2]Used as basis for calculating the force reductions at the 6 percent moisture level.
[3]Used as basis for calculating the force reductions at the 4 percent moisture level.

The maximum tie force exerted by bales can also be reduced by uniformly distributing the lint cotton in the press box. When the lint cotton is very unevenly distributed in the press box, one tie may have over 300 percent more force exerted on it than another tie on the same bale. The force used to compress lint cotton and the type of bale ties used to restrain lint cotton can be varied to compensate for low moisture or large bales.

Another viable method of reducing bale tie stress is to control lint moisture. Maintaining lint moisture in the range of 6–8 percent at the press can appreciably reduce the press energy consumption and bale tie forces. Increasing moisture from 5 to 8 percent will reduce the press force required and the press electrical energy consumption by about 25 percent. The bale tie force will be reduced about 20 percent.

There are several devices for adding moisture to the lint prior to entering the lint into the press. They range in moisture restoration capacity—some can increase lint moisture as much as 5 percent. Moisture restoration is more easily accomplished when the ambient temperature is low. However, low ambient temperature increases the problem of moisture condensation on any metal that comes in contact with the moisture laden lint. To overcome this problem, all surfaces that contact the humidified lint should be heated or insulated.

Special care must be taken to ensure that the bale ties are not overstressed. Broken bale ties can be quite expensive to replace, since the bale must be repressed before a new tie can be applied.

Bale ties should be of sufficient strength to restrain bales of cotton transported from the gin to the textile mill. Specifications for bale ties (wire and flat-metal bands) are published annually by the Joint Cotton Industry Bale Packaging Committee sponsored by the National Cotton Council (National Cotton Council 1992). Revised specifications must be consulted annually to ensure conformance with current requirements. These specifications are mandatory for entry of bales into the Commodity Credit Corporation loan program.

Bale Tie Systems

Traditionally, most bale tying at cotton gins was done manually, and hot-rolled steel bands about 1 inch wide were universally used. Two developments greatly influenced materials and methods used to tie out bales at the gins. First, trade regulations for upland cotton were changed from gross weight trading to net weight trading. Under the old gross weight trading system, 21 lb of tare were allowed. There were strong economic incentives to use heavy ties as well as heavy bale cover materials that together weighed about 21 lb. Therefore, heavy, hot-rolled steel bands were almost universally used. Under net weight trading, the economic incentives then called for the least expensive tie materials to be used. However, at that time most cotton bales produced in the United States passed through a two-stage process in which the cotton was first pressed to flat bale density (12-14 lb/ft^3) at the gins and later compressed to standard density (22–24 lb/ft^3) or high density (32 lb/ft^3) for overseas shipments. In this two-stage system, the compresses reused the six long ties from the flat bales produced at the gins. These six long ties were cut to shorter lengths when put on the smaller compressed bales, and the six leftover short pieces of wire were spliced together, providing two or three additional ties (making a total of eight or nine ties) to contain the standard or high-density bales.

The second development that influenced bale tying was the adoption of the universal density bale. Universal density bales could be produced either by the then conventional two-stage system or by the single-stage process using a universal density press at the gin. Most gins in the United States now have universal density presses, which, unlike the presses in the two-stage system, allow all types of tie materials to be used.

Largely as a result of these two developments, a variety of bale tie materials and tying systems are now in use. The two major tie materials used are cold-rolled strapping and wire with preformed loops on the ends that form a square-knot connection. The cold-rolled strapping can be manually or automatically applied. The preformed wire can be applied manually or semiautomatically.

When cold-rolled strapping ties are used, the material is 5/8 to 3/4 inch wide. The simplest manual system used with cold-rolled strapping employs precut straps with the ends prepunched to form interlocking slots that may be hand connected. To put less strain on the connections, the strap may be rotated around the bale so that the connection lies between the crown and the edge of the bale. Normally eight straps are used, but some bales have only six straps.

Fully automatic tying systems employ cold-rolled strapping from coils. In these systems, six or eight ties are used. Anywhere from two to four strapping machines are normally mounted on an indexing mechanism in which each strapping machine, or head, applies two to four ties.

The simplest system used with cold-rolled wire with preformed end loops is completely manual. The wire is passed around the top, bottom, and one side of the bale, and the square knot connection is manually made along the other side of the bale. This process requires a person to have considerable dexterity and strength; therefore, semiautomatic wire tying systems are commonly used.

One such system employs knotter devices in the top platen of the press. One looped end of the wire is fed into one side of the top platen and hooked in the knotter device. The free end of the wire is then fed around the bale. A 90° bend is manually formed about 6–8 inches from the free end of the wire, allowing the operator to push the end horizontally into the top platen knotter device. When the end is pushed into the device, the two looped ends of the wire are brought together, making the square-knot connection. This system reduces much of the dexterity and strength required and has a further advantage in that the knot is now located on the top of the bale without having to rotate the stiff wire after making the knot, as in the purely manual system.

Another semiautomatic wire-tying system employs chutes on the side of the bale opposite where the operator or operators stand, thus allowing the wires to be inserted from one side of the bale. The chutes then return the wires back to the operators. A power assist device draws the wire up tight to make the square-knot connection.

Still another semiautomatic wire-tying system removes practically all the manual effort and has the further advantage of forming the knot on the bottom crown of the bale. It can accommodate capacities of over 60 bales/hr with only one operator. This system employs “arms” on both sides of the top platen of the press—one pair of arms for each tie. These arms are pivotally mounted to the top platen and move from an outstretched position to a down position along the sides of the bale. Near the outer ends of the arms are “wrists” that also pivot as the arms lower from their outstretched positions. Thus the wrist movement causes the extremities of the arms to pass into slots in the bottom platen, where knotter devices are located. One operator loads the 6 or 8 wires in the arms when the arms are in the outstretched position, forming a straight line with the slots in the top platen. This is done while the previous bale is ejecting, the bottom ram is descending, and the press boxes are rotating; thus the loading of the wires does not interfere with the press cycle. When the next bale is fully compressed, the arms move down, forming two 90° bends in the wires on each side of the bale and pushing the loop ends of the wires together in the bottom press platen knotter device to make the square-knot connection. The arms then return to their up, or outstretched, position. The complete tying action takes less than 10 sec.

In all these strapping and wire-tying systems, the bales are generally strapped naked; this reduces personnel exposure to the moving parts of the baling press and strapping mechanism and increases the capacity of the baling operation with minimum labor requirements. Even so, personnel working around a baling press should be protected by face shields, and switch mats or other devices that prevent hazardous machine motions should be used when personnel might be in the area.

Analysis of Cotton Bale Tie Failures

Excessive cotton bale tie failures at gins and during shipping and warehousing place unnecessary financial strain on the cotton industry. Analysis of the cause of failures on bales from specific gins is not simple and direct because many factors affect the forces on restraining ties. For a systematic guide to determine the cause of bale tie failures, see Anthony (1982a). A copy of Anthony (1982a) can be obtained from the U.S. Cotton Ginning Laboratory, P. O. Box 256, Stoneville, MS, 38776.

Analyses of the potential causes of bale tie failure must account for the three main factors (platen separation, lint moisture, and bale circumference) that govern the stresses within the bale ties. A decision matrix to resolve the cause of excessive bale tie failures is given in figure 5–60. The decision matrix can be used alone and requires minimal information within the decision blocks. The matrix cannot be used for isolated bale tie breakages that involve a few bales at random, but it can be used to locate causes when failures occur repeatedly. Further analysis of bale tie breakage is needed in complex cases (Anthony 1982a).

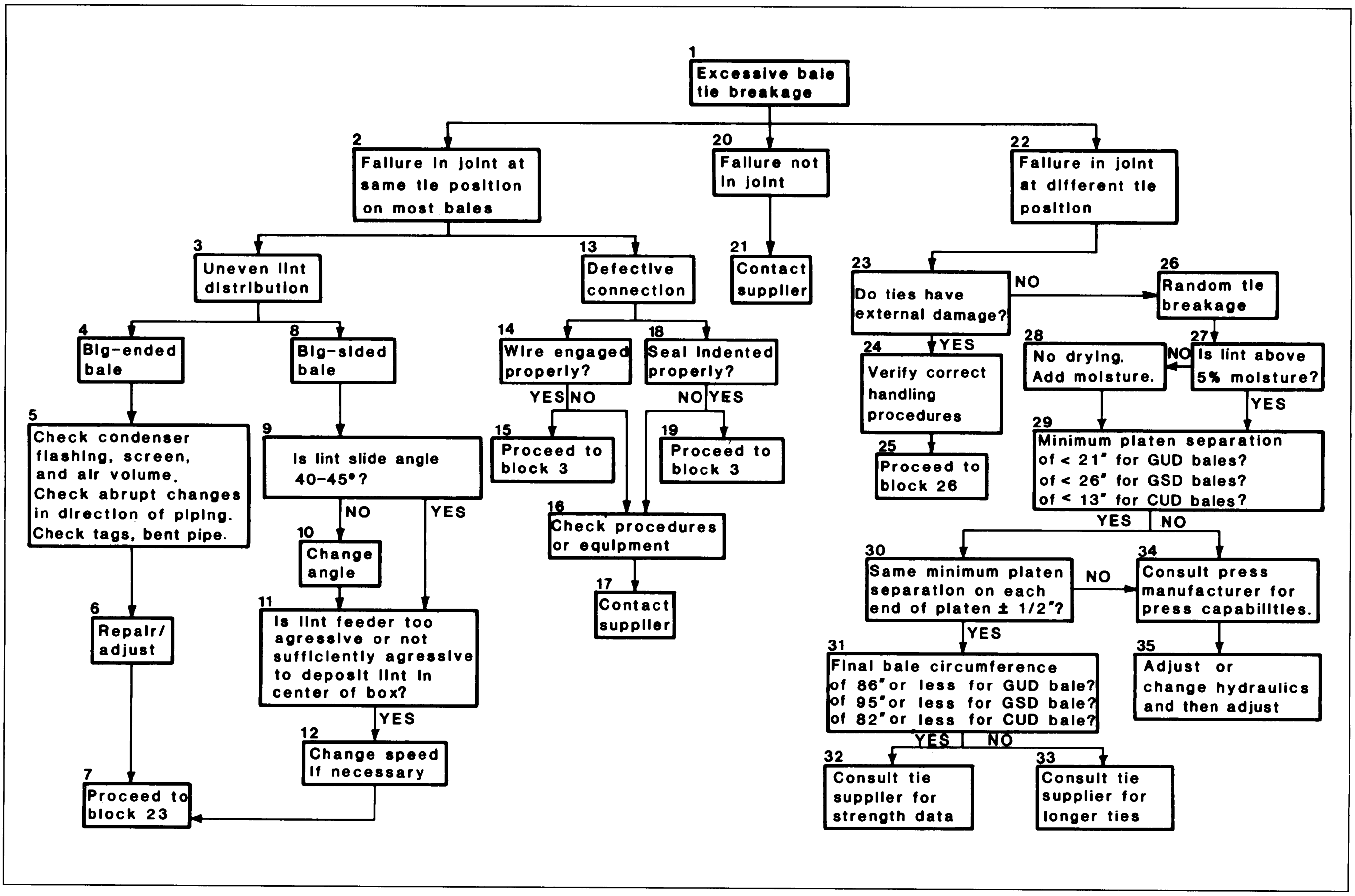


Figure 5–60. Decision matrix for analysis of the cause of excessive tie failures in cotton bales. *GUD*, Gin universal density; *GSD*, gin standard density; *CUD*, compress universal density.

Bale Handling Systems

Most medium- and high-capacity cotton gins have power-operated bale handling systems to remove the bales from the presses and convey them to their wrapping and weighing stations. From this point, the bales are often conveyed on their flat sides to a bale loading dock or adjacent warehouse, where they are downended to stand on their heads and accumulated in a row. A clamp truck then picks up four or more bales at a time to load the bales into waiting trucks, boxcars, adjacent warehouses, or bale yards. These systems generally incorporate devices for facilitating the wrapping, weighing, and tagging of bales and for recording the bale information.

A variety of conveying systems are employed from the bale wrapping and weighing station; the system used depends upon the layout of the gin plant. In the simplest systems, the wrapped, weighed, and tagged bales move on a conveyor only a few feet through the gin wall where they are downended and moved by a pusher, sliding on their heads to form a row of bales butted together. The pusher also makes room for the next bale to be downended from the conveyor. In other systems where the bale warehouse or loading dock is more remote, the bales may ride on their flat sides on various roller conveyors, changing direction through bale turners and, in some cases, riding over elevated conveyor systems across roadways or other obstructions to reach their final destination.

Starting at the baling press, the first part of the bale handling system automatically ejects the bale out of the press. In uppacking presses this is generally accomplished by a very simple device that tilts one or more platen bars as the following block lowers. In downpacking presses, one or more bottom-plated bars are tilted by a pneumatic or hydraulic cylinder to eject the bales from the press. These bale ejection devices are coordinated with one of two means to remove the bales from the press area and convey the bales to the bale wrapping station. With uppacking presses, in which the box is turned below floor level, a pair of conveyor chains, running from the press bale discharge point over to the bale wrapping station, is commonly used. Optionally, a bale dolly, which runs on tracks in the floor, may be used to receive the bale from the press and carry the bale to the bale wrapping station. Because the bales are usually ejected from an uppacking press very close to the floor level the bale dolly will normally have a tilting top so that it receives the bales at a low level and in an inclined position. The dolly then tilts the bales up to a horizontal position as it moves toward the bale wrapping station.

On downpacking presses, the bale dolly system is normally used because the bale is ejected from the press at a higher level from the floor. The bale dolly may have a nontilting top surface on which the bale can fall on its flat side. The top horizontal surface of the dolly is at a fixed level from the floor and is at the proper height for receiving the bale at the press and for aligning the bale with the bale wrapping station.

To be accepted in the trade, bale wraps must completely cover the bales on all six sides. To accomplish this, a simple and efficient system, commonly called the bale stuffer system, is used. This system employs two vertically hinged, funnellike panels over which a preformed bag of wrapping material is manually placed. A bale pusher foot, mounted on a carriage that rides either above or below the bale and that is driven by a chain drive, pushes the bale off the dolly or rollers on which the bale is resting. This motion is at right angle to the movement of the bale from the press to the entrance of the bale wrapping station. As the bale moves into the bale stuffer, the side panels hinge outward under the pressure of the bale, acting much like shoe horns by causing the bale to be inserted tightly into the preformed bag. The bale pusher continues to advance the bale until it is completely out of the bale stuffer station. At this point, the bale usually rests on a weigh scale, where the bale is weighed and, usually, the open end of the bag is sewn closed either manually or with a sewing machine suspended overhead. The bale pusher foot, which is backed away from the bale during the sewing and weighing operation, now advances the bale onto powered conveyors that carry the bale to its down ending point, or, in the case of close-coupled installations, the bale pusher foot moves the bale directly to the down-end point. The bale tags are usually affixed to the bale wrap material at the weigh station, but, in some close-coupled installations, the bale is first downended before the bale tag is affixed and before the open end of the cover is sewn closed.

A variety of bale covering materials are approved by the National Cotton Council Bale Packaging Committee and the Commodity Credit Corporation. The material must protect the bale from contamination from outside sources by resisting abrasion and tearing. The bale cover material must also not cause contamination of the cotton; fibers or strips of the cover must not adhere to the bale surface. The cover material must be porous enough to allow water to seep out in case the bale is exposed to rain. Furthermore, the porosity of the material should be such that the cotton within will come to equilibrium relatively quickly with atmospheric moisture conditions.

Bale samples must be drawn in such a way that the bale cover material does not leave exposed cotton areas. A simple and efficient system for drawing bale samples uses devices in the top and bottom platens of the press, commonly called cookie cutters. These are simply plates of steel approximately 1/4 inch thick and about 6 inches by 12 inches with flanges turned up on three sides about 1 inch high. The edges of these flanges are sharpened so that when the bale is pressed the compression force cuts neat plugs of cotton. These plugs are temporarily held in place by the one uncut side so that the press operators can easily reach over and tear the samples from the sides of the bale. It is most important that these operators wear protective face and arm shields. Bales fresh from the baling press are most likely to have their ties break. When ties break, they can whip out with considerable force and cause severe injury to personnel who are not wearing protective shields.

These bale handling systems in which the bale cover is affixed outside the press and the bale is weighed and conveyed with the use of automated mechanisms as described above are a major contributing factor to high-capacity ginning with reduced labor and reduced hazard to personnel.

Bale Covering

Bales should be fully covered, and all bale covering material should be clean, in sound condition, and of sufficient strength to adequately protect the cotton. The material must not have salt or other corrosive material added and must not contain sisal or other hard fiber or any other material that will contaminate or adversely affect cotton. Recommended bale coverings are published annually by the Joint Cotton Industry Bale Packaging Committee and should be consulted for current guidance.

Since the adoption of net weight trading the weight of bale packaging materials has declined. In 1990, the tare weights shown in table 5–13 were established for all bales in the United States meeting the specifications for acceptance in the Commodity Credit Corporation loan program (National Cotton Council 1988).

Table 5–13.
Tare weights for various combinations of approved bale covering and restraint materials

	Tare weight (lb)		
Bale covering materials	Keylock-type or controlled-slip steel strapping (6 ties)	Keylock-type, controlled-slip steel strapping, or wire (8 ties)	Fixed-seal steel strapping
Woven polypropylene[1] and linear low-density polypropylene[2]	4	5	6
Low-density polyethylene[3]	5	6	7
Burlap or cotton spiral bags[4]	6	7	8
New jute and salvage jute bagging[5]	10	11	12

[1]Woven polypropylene can be identified by its pale yellow color. This category includes all patterns of polypropylene, including two sheets, bag and sheet combinations, and spiral sewn bags.
[2]Linear low-density polyethylene bags can be identified by the clear color and the words "100% linear low-density polyethylene" or "100% LLDPE" printed on each bag. Total tare weight is printed on the bag.
[3]Polyethylene bags can be identified by the clear color. Total tare weight is printed on the bag.
[4]Burlap spiral bags can be identified by the lightweight burlap fabric sewn to form a bag that completely encloses a bale. Cotton bagging is any package material made from all cotton fiber.
[5]Salvage jute is commonly referred to as sugar bagging and can be identified by seams and markings indicating that the material was previously used for other commodities.

Moisture Change in Cotton Bales

Cotton is usually dried, cleaned, ginned, and packaged at a moisture content well below its eventual equilibrium moisture content in storage. The moisture content and other physical responses of cotton to environmental conditions vary depending primarily upon the surrounding atmosphere (Hearle and Peters 1960, Griffin 1974).

When the humidity of the storage environment is higher than the humidity within the bale, the bale will gain moisture until it equilibrates with the environment. As the bale gains or loses moisture during storage, the weight of the bale changes. The rate of moisture gain is significantly influenced by the density of the cotton bale. Modified flat bales have a lower density (14 lb/ft^3) than universal density bales (28 lb/ft^3) and gain moisture more rapidly (Anthony 1982b). The rate of moisture gain is also influenced by the type of bale covering. The rates of moisture gain for bales covered with polypropylene, burlap, and extrusion-coated polypropylene are similar. Figure 5–61 depicts the change in bale weight over time for bales covered with woven polypropylene or polyethylene and ginned at 4.5 percent moisture. Bales of

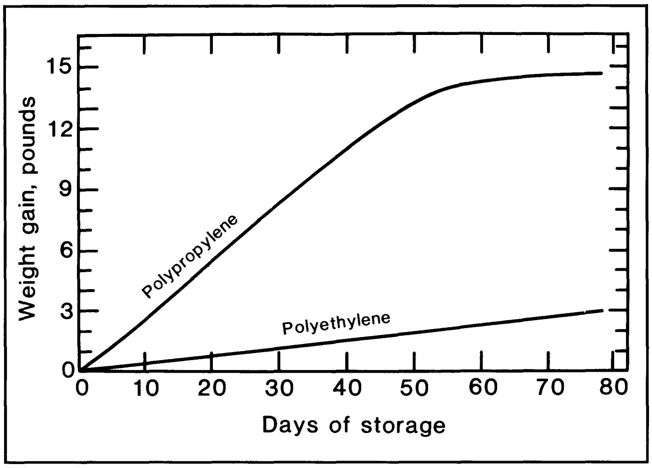


Figure 5–61. Weight gain of 500-lb universal density cotton bales covered with woven polypropylene or polyethylene and stored at 75 °F and 75 percent relative humidity. Initial moisture content of the bales was 4.5 percent, wet basis.

cotton ginned at less than 5 percent lint moisture, covered with polypropylene, and stored for over 60 days at high humidities (75–80 percent) will absorb about 10–15 lb of water, which will increase the lint moisture by up to 7 or 8 percent.

Safety Tips for Packaging Cotton

The following guidelines can help prevent serious accidents:

1. Avoid contact with gin machinery.

2. Become familiar with warning devices (horns, buzzers, etc.) before working on any part of the gin. Ask your supervisor if you have any questions about what each warning device means or how it is used. Obey all warning signs.

3. Prior to startup, make certain that all personnel are clear of the machinery. Sound the warning device 10 sec for other workers to get clear of machinery before starting the press.

4. Before you inspect, clean, adjust, or maintain any gin machinery, cut off and lock out all power at the master disconnect switch. Put your personal lock on each switch box, and put the keys in your pocket. After lockout, do not reach inside the guards or machine until you are certain all motion has stopped.

5. Be sure that the interlocks on the tramper doors are operational. Never put any part of your body inside the press box or lint slide unless the master disconnect switch is locked out.

6. Do not place any part of your body beneath the followblock while the ram is in motion.

7. Do not enter a press pit or any platform on the press while the power is on. Where possible, the same holds true for any platform on the press.

8. Stand back from the rotating press circle and the doors that automatically open.

9. Stay at least 5 ft from bales as the ram is released because ties may break.

10. Stand clear as bales are ejected and conveyed through the gin.

11. If you are manually strapping a bale or working close to a bale, wear protective clothing, face protection, and gloves.

12. When automatic strapping heads are in use, do not place any part of your body between the heads and the end or center columns of the press.

13. Never attempt to make hydraulic system repairs with a bale in the press or with the ram in any position other than completely retracted. Hold the followblocks in position with blocks or straps.

14. Bleed off pressure and then use extreme caution when disconnecting flexible hoses or other hydraulic fittings. Do not alter settings on relief valves or pressure switches. Use only recommended oils and fluids in hydraulic systems. Do not use highly volatile fluids for cleaning.

15. Be aware that many presses are automated and can start into motion at any time without warning—be alert. Electrical controls are not perfect!

16. Remember that as much as 1 million lb of force may be required to compress a bale of cotton. Forces in bale ties may exceed 2,000 lb. Be aware of the dangers associated with the forces involved in bale packaging operations.

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SECTION 6— MATERIALS HANDLING

Pneumatic and Mechanical Handling Systems

R.V. Baker, E.P. Columbus, R.C. Eckley, and B.J. Stanley

Cotton gins use the movement of air to propel seed cotton, cottonseed, trash, and lint through conveying pipes much like the wind blows leaves, dirt, and other materials in nature. In gins, pneumatic conveying systems are very important because they are the principal means by which gins move materials from one processing stage to another throughout the entire ginning plant (McCaskill et al. 1977). When the conveying air is heated or humidified, the pneumatic conveyor becomes a drying or moisture adding system.

Cotton gins use enormous quantities of air for pneumatic conveying. It is not uncommon for a gin to use 150,000 ft^3 or more of air per minute in its various conveying processes. Since air weighs 0.075 lb/ft^3 at standard conditions, a gin can easily handle 11,250 lb air/min or 675,000 lb/hr. This weight of air per hour usually exceeds the total weight of seed cotton handled per hour by severalfold. Thus, it is understandable why these air systems consume over half of the total power required in a modern cotton gin. It is also obvious why it is so important to maximize the efficiency of pneumatic systems. Efficient pneumatic systems not only lessen the gin's energy costs but also promote smooth, trouble-free ginning with a minimum of downtime.

Air Facts Ginners Should Know

There are a few major definitions and facts that a ginner should keep in mind when dealing with pneumatic conveying systems. An understanding of these facts will greatly enhance efforts to conserve energy and keep the systems operating properly.

1. Air velocity is defined as the speed of a moving airstream. In the gin air velocity is determined by measuring the pressure produced by the moving airstream as it impacts a special measuring device known as a pitot tube. This pressure is called the velocity pressure. One must have air movement in order to have velocity pressure, and velocity pressure is always positive.

2. The pressure that exerts a force on the inside walls of the conveying pipe is known as the static pressure. It is completely independent of the velocity pressure and may therefore exist in the absence of velocity pressure. A common example of static pressure is the pressure inside a compressed-air tank. In a pneumatic conveying system the static pressure may be either positive or negative depending upon whether the measurement is taken on the discharge or suction side of the fan.

3. The total pressure in a conveying pipe is simply the sum of the velocity and static pressures and may be either positive or negative.

4. The velocity, static, and total pressures are normally measured in units of inches of water with a liquid manometer or Magnehelic gauge. A pressure of approximately 27.7 inches of water (in. W.G.) is equivalent to that of 1 pound per square inch (psi).

5. The total volume of air flowing through a conveying pipe is determined by multiplying the air velocity (in ft/min) by the cross-sectional area (in ft^2) of the pipe. One must keep in mind that the flow of air in a pipe is similar to the flow of water in a pipe, although total airflow volume is measured in cubic feet per minute rather than in gallons per minute.

6. The conveying ability of a pneumatic system depends on several factors, but air velocity is of particular importance. The faster the airstream is moving, the more force it exerts on the material being conveyed. Therefore, it is crucial that sufficient air velocity be maintained throughout the conveying system in order to keep the conveyed material moving properly.

7. Air flows from high-pressure to low-pressure areas. In a pneumatic conveying system a fan is used to create the pressure differentials required to induce airflow. The pressure differential needed for a required airflow depends on the size, shape, and frictional characteristics (including number of elbows) of the piping system as well as the nature of the material to be conveyed. This pressure requirement, usually called static pressure demand, and the total airflow requirements determine the size and operating speed of the fan.

8. Most cotton gin centrifugal fans operate at static pressure demands below 27.7 inches of water (at 1 psi).

9. Where pipe lengths are equal and where equal flow of air is handled, smaller pipes have greater frictional resistance or static pressure demand than do larger pipes (fig. 6–1) and therefore require more power.

10. Elbows in a piping system greatly increase the system's static pressure demand. The box below shows the equivalent straight-pipe resistance for 90° elbows (round duct):

Throat radius of elbow in pipe diameters	1/2	3/4	1	1-1/4	1-1/2	2	3
Diameter of straight pipe offering equivalent resistance	17	14	12	11	9.7	8.5	6.5

For example, a 16-inch-diameter 90° elbow with a throat radius equal to 1-1/2 pipe diameters (24 inches) has the same resistance to airflow as 9.7 diameters (or 12.9 ft) of straight pipe. A system containing 5 such elbows will

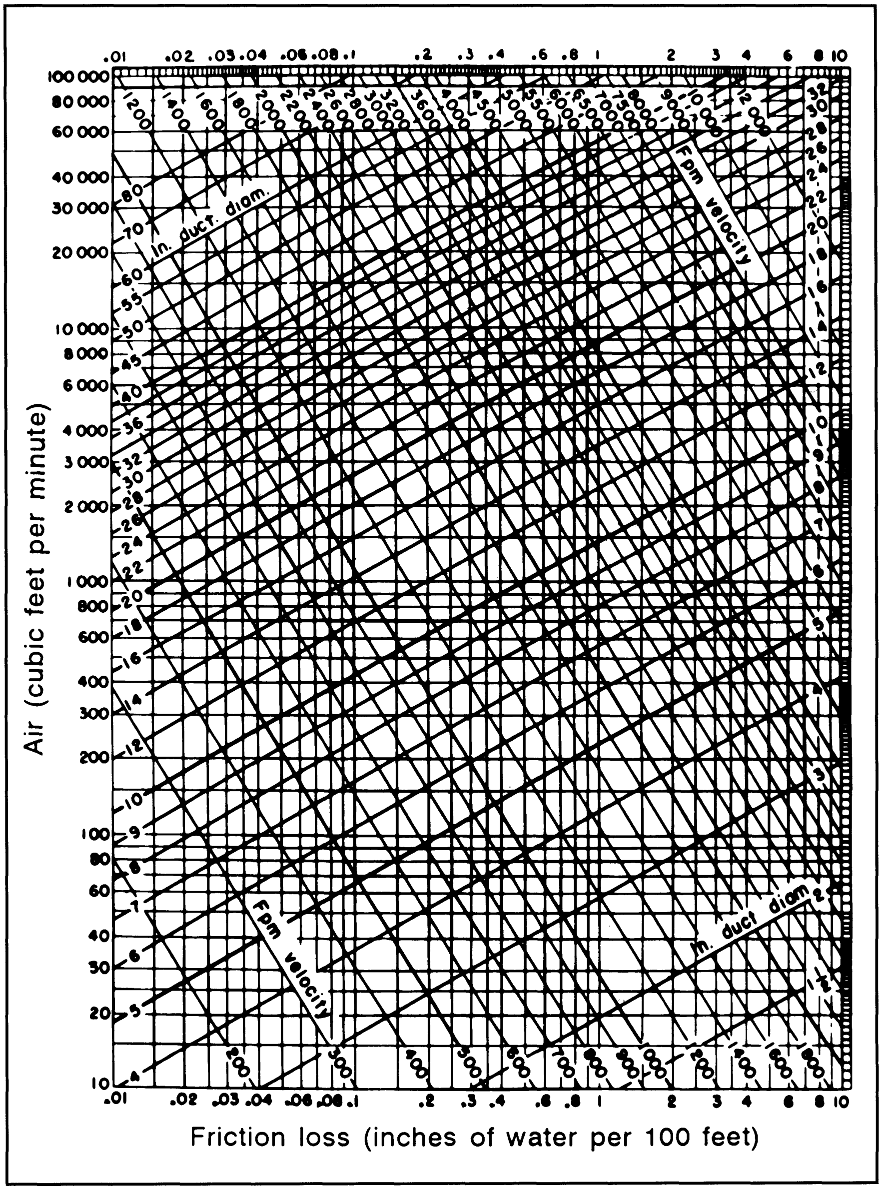


Figure 6–1. Friction loss in round pipe per 100 ft of length

have an increased resistance equal to that of 48.5 diameters (or 64.7 ft) of straight pipe. For bends of less than 90° the equivalent straight-pipe resistance is in proportion to the bend. For example, a 60° bend will have two-thirds of the equivalent resistance of a 90° bend.

Piping

In cotton gins, air and material are directed through 18- to 24-gauge sheet metal pipes that vary in diameter from 8-36 inches. Piping systems must be carefully planned to achieve desired results and properly maintained to avoid excessive horsepower consumption. Some useful rules to follow are

1. Make piping as simple and direct as possible, eliminating unnecessary elbows and valves.

2. Keep pipe joints as airtight and rigid as possible to minimize air leakage, to reduce horsepower requirements, and to save money for the ginner. However, some leakage is unavoidable. Therefore, airflow calculations should make provisions for normal leakage. Up to 35 percent leakage can occur through a vacuum dropper; and tower dryers, bolltraps, and cylinder cleaners also frequently leak. Provisions must be made when sizing the fan to account for such leakage.

3. Reduce fan speeds to reduce excessive airflow volumes and to lower power consumption. Cutting holes in pipes to relieve pressures or to increase airflow is usually unsatisfactory.

4. Allow about 15–20 ft^3 air/lb of conveyed material for fans used in the unloading system or in any piping system used strictly for conveying. This air volume may have to be increased when handling very wet, trashy cotton or when air leakage is greater than normal. Also, cotton drying systems are often designed to provide 20–40 ft^3 air/lb of cotton to enhance drying effectiveness.

	Air velocity (ft/min)
Seed cotton in telescope pipe	5,500–6,000
Seed cotton in conveying pipes	3,500–5,000
Seed cotton in tower dryers	2,000–2,500
Seed in small-pipe systems	4,000–5,000
Hulls and trash	4,000–5,000
Lint cotton	1,500–2,000

The box on the left shows air velocities required for efficient conveying of various materials handled by cotton gins.

Excessively high conveying velocities should be avoided in order to protect seed quality. Air velocities used for conveying seed cotton and seed should be maintained within the ranges recommended above to avoid cracking or shattering seed when the material impacts sharp-turn elbows, separator reels, and other objects. It is good practice to use elbows with as long a throat radius as possible in lines conveying seed cotton and seed. This consideration is especially important for the small-pipe, high-pressure seed handling systems.

The number, size, and operating rate of gin stands will determine the required rate of flow of seed cotton in the gin (usually 8–40 bales/hr). This flow rate and the layout of the gin machinery will determine the dimensions and arrangement of the piping (table 6–1). The air pressures needed to overcome the resistance of equipment and pipes and the quantities of cotton needed to supply the gins will determine the required fan capacity.

Table 6–1.
Typical seed cotton conveyor-pipe sizes used in gins of different capacities and layouts[1]

Ginning capacity (bales/hr)	Pipe diameters (inches)	
	Single-stream layout	Split-stream layout
6–10	14	(2)
11–15	16	Two 13's
16–20	18	Two 14's
21–25	22	Two 16's
26–30	24	Two 17's
31–35	(2)	Two 19's
36–40	(2)	Two 20's

[1]Based on an air velocity of 4,500 ft/min.
[2]Not normally used.

Air Measurements

Even when fan speed, fan wheel diameter, and other factors are known, it is difficult to predict fan performance accurately. The only reliable way to determine how a fan is performing and to determine a system's characteristics is by making air measurements. Because pneumatic systems in gins vary greatly (no two installations are identical) each system requires different procedures to be followed when air measurements are made. However, the necessary determinations can be made with a relatively simple kit containing the following items:

1. A 5/16-inch-diameter standard or a 1/8-inch-diameter pocket-size pitot tube

2. A liquid manometer or differential pressure gauge

3. Two rubber or plastic hoses to connect the pitot tube to the manometer

4. A speed indicator for measuring fan speeds

5. A measuring tape for determining pipe diameters

6. Tables of airflow for various pipe diameters and velocity pressures

7. An amp meter to check fan motor electrical current.

Airflow and operating pressures in a piping system must be determined by making air readings at the fan inlet and discharge. Since a fan may be used either for suction or for blowing through pipes, pressure readings should be taken at both the fan inlet and outlet to determine the overall static and total pressure across the fan. An outlet reading is all that is necessary on a fan used only for blowing. Readings may also be taken wherever information is needed, such as at troublesome points in a piping system or at separator inlets and outlets to determine whether leakage is occurring. Test holes should be located a minimum of 8-1/2 pipe diameters downstream and 1-1/2 pipe diameters upstream from elbows and valves when possible.

The following are directions for using the test kit:

1. Connect the manometer or gauge to the pitot tube with the two lengths of flexible hose.

2. Insert the pitot tube into the test hole until the nose reaches the center of the pipe. Keep the stem of the pitot tube at a right angle to the pipe while the nose of the tube points upstream into the air current. Determine the velocity pressure (Pv) by measuring the difference in liquid levels between the two columns of the manometer or by reading the differential pressure gauge if that instrument is being used. Since the manometer levels or gauge readings usually fluctuate, take several measurements or readings and then average them.

3. Disconnect the total pressure hose from the pitot tube, and leave the static pressure outlet connected (the static pressure outlet on the pitot tube is perpendicular to the stem). Insert the pitot tube into the pipe in the same manner as described in procedure 2 above, and read the static pressure (Ps). This reading may be checked by withdrawing the pitot tube and holding the end of the flexible hose over the test hole in the pipe. The two static pressure readings should be nearly the same.

4. Repeat procedure 3 on the opposite side of the fan, and add the two static pressure readings (regardless of whether they are positive or negative) to obtain the overall static pressure.

After the Pv reading has been obtained (step 2), the velocity of the air (in ft/min) and the volume of the air (in ft^3/min) that the fan is delivering can be estimated from tables 6–2 or 6–3. The left-hand column of these tables gives Pv, and the second column gives the velocity that corresponds to the Pv regardless of pipe diameter. The body of each table gives the volume of air (in

Table 6–2.
Air velocities and volumes associated with various velocity pressures (Pv) in conveying pipes[1]

Pv (inches of water)	Velocity[2] (ft/min)	Air volume[3] (ft^3/min) for pipe diameter of: 8"	9"	10"	11"	12"	13"	14"	15"	16"	17"	18"	19"	20"	22"	24"
0.1	1,154	403	510	630	762	907	1,064	1,234	1,416	1,612	1,819	2,040	2,273	2,518	3,047	3,626
0.2	1,632	570	721	890	1,099	1,282	1,505	1,745	2,003	2,279	2,573	2,885	3,214	3,561	4,309	5,128
0.3	1,999	698	833	1,090	1,319	1,570	1,843	2,137	2,453	2,791	3,151	3,533	3,936	4,362	5,277	6,281
0.4	2,308	806	1,020	1,259	1,523	1,813	2,128	2,468	2,833	3,223	3,639	4,079	4,545	5,036	6,094	7,252
0.5	2,581	901	1,140	1,408	1,703	2,027	2,379	2,759	3,167	3,604	4,068	4,561	5,082	5,631	6,813	8,108
0.6	2,827	987	1,249	1,542	1,866	2,221	2,606	3,022	3,470	3,948	4,456	4,996	5,567	6,168	7,463	8,882
0.7	3,054	1,066	1,349	1,666	2,015	2,398	2,815	3,265	3,748	4,264	4,814	5,397	6,013	6,662	8,061	9,594
0.8	3,265	1,140	1,442	1,781	2,154	2,564	3,009	3,490	4,006	4,558	5,146	5,769	6,428	7,122	8,619	10,256
0.9	3,463	1,209	1,530	1,889	2,285	2,720	3,192	3,702	4,249	4,835	5,458	6,119	6,818	7,554	9,141	10,878
1.0	3,650	1,274	1,613	1,991	2,409	2,867	3,364	3,902	4,479	5,096	5,753	6,450	7,187	7,963	9,635	11,467
1.1	3,828	1,336	1,691	2,088	2,526	3,007	3,529	4,092	4,698	5,345	6,034	6,765	7,537	8,352	10,106	12,026
1.2	3,998	1,396	1,766	2,181	2,639	3,140	3,686	4,274	4,907	5,583	6,302	7,066	7,873	8,723	10,555	12,561
1.3	4,162	1,453	1,839	2,270	2,746	3,269	3,836	4,449	5,107	5,811	6,560	7,354	8,194	9,079	10,986	13,074
1.4	4,319	1,508	1,908	2,356	2,850	3,392	3,981	4,617	5,300	6,030	6,807	7,632	8,503	9,422	11,401	13,568
1.5	4,470	1,560	1,975	2,438	2,950	3,511	4,121	4,779	5,486	6,242	7,046	7,900	8,802	9,753	11,801	14,044
1.6	4,617	1,612	2,040	2,518	3,047	3,626	4,256	4,936	5,666	6,446	7,277	8,159	9,090	10,073	12,188	14,504
1.7	4,759	1,661	2,102	2,596	3,141	3,738	4,387	5,087	5,840	6,645	7,501	8,410	9,370	10,383	12,563	14,951
1.8	4,897	1,709	2,163	2,671	3,232	3,846	4,514	5,235	6,010	6,837	7,719	8,654	9,642	10,684	12,927	15,384
1.9	5,031	1,756	2,223	2,744	3,320	3,950	4,637	5,378	6,174	7,025	7,930	8,891	9,906	10,976	13,281	15,806
2.0	5,162	1,802	2,280	2,815	3,407	4,054	4,758	5,518	6,335	7,207	8,136	9,122	10,163	11,261	13,626	16,217
2.1	5,289	1,846	2,337	2,885	3,491	4,154	4,875	5,654	6,492	7,385	8,337	9,347	10,414	11,540	13,963	16,617
2.2	5,414	1,890	2,392	2,953	3,573	4,252	4,990	5,787	6,644	7,559	8,534	9,567	10,660	11,811	14,291	17,008
2.3	5,535	1,932	2,446	3,019	3,653	4,348	5,102	5,918	6,793	7,729	8,725	9,782	10,899	12,077	14,613	17,390
2.4	5,655	1,974	2,498	3,084	3,732	4,441	5,212	6,045	6,939	7,895	8,913	9,992	11,134	12,336	14,927	17,764
2.5	5,771	2,015	2,550	3,148	3,809	4,533	5,320	6,169	7,082	8,058	9,097	10,198	11,363	12,591	15,235	18,131
2.6	5,885	2,054	2,600	3,210	3,884	4,622	5,425	6,292	7,223	8,218	9,277	10,400	11,588	12,840	15,536	18,490
2.7	5,998	2,094	2,650	3,271	3,958	4,710	5,528	6,411	7,360	8,374	9,454	10,599	11,809	13,085	15,832	18,842
2.8	6,108	2,132	2,698	3,331	4,031	4,797	5,630	6,529	7,495	8,528	9,627	10,793	12,026	13,325	16,122	19,188
2.9	6,216	2,170	2,746	3,390	4,102	4,882	5,729	6,645	7,628	8,679	9,798	10,984	12,238	13,561	16,408	19,527
3.0	6,322	2,207	2,793	3,448	4,172	4,965	5,827	6,758	7,758	8,827	9,965	11,172	12,448	13,792	16,689	19,861

[1]Based on standard air conditions (70 °F, 29.92 inches Hg) and 1 center-of-the-pipe pitot tube reading (4,005 x 0.9113 = 3,650).
[2]Velocity (ft/min) = 3,650 x velocity pressure (inches $H_2O)^{0.5}$.
[3]Volume of air (ft^3/min) = velocity (ft/min) x area of pipe (ft^2).

Table 6–3.
Air velocities and volumes associated with various velocity pressures (Pv) in condenser exhaust pipes[1]

Pv (inches of water)	Velocity[2] (ft/min)	Air volume[3] (ft^3/min) for pipe diameters of: 21"	26"	28"	29"	30"	32"	36"	42"	48"	54"
0.1	1,154	2,776	4,256	4,936	5,293	5,666	6,445	8,157	11,103	14,502	18,354
0.2	1,632	3,926	6,018	6,980	7,486	8,013	9,115	11,536	15,702	20,508	25,956
0.3	1,999	4,809	7,371	8,549	9,169	9,813	11,164	14,130	19,233	25,120	31,793
0.4	2,308	5,553	8,511	9,871	10,587	11,332	12,890	16,314	22,206	29,003	36,707
0.5	2,581	6,208	9,516	11,036	11,839	12,669	14,415	18,244	24,832	32,434	41,049
0.6	2,827	6,800	10,424	12,090	12,967	13,878	15,789	19,983	27,199	35,525	44,961
0.7	3,054	7,345	11,259	13,058	14,009	14,990	17,057	21,587	29,383	38,378	48,572
0.8	3,265	7,852	12,037	13,960	14,976	16,025	18,235	23,079	31,413	41,029	51,928
0.9	3,463	8,329	12,767	14,807	15,885	16,997	19,341	24,479	33,318	43,517	55,077
1.0	3,650	8,779	13,458	15,608	16,742	17,917	20,385	25,800	35,117	45,867	58,051
1.1	3,828	9,208	14,114	16,369	17,559	18,791	21,380	27,059	36,830	48,104	60,882
1.2	3,998	9,617	14,742	17,097	18,339	19,627	22,329	28,260	38,465	50,240	63,585
1.3	4,162	10,010	15,344	17,795	19,091	20,428	23,245	29,419	40,043	52,301	66,194
1.4	4,319	10,388	15,923	18,467	19,811	21,200	24,122	30,529	41,554	54,274	68,691
1.5	4,470	10,752	16,482	19,115	20,504	21,944	24,965	31,597	43,006	56,172	71,092
1.6	4,617	11,105	17,023	19,742	21,178	22,663	25,786	32,636	44,421	58,019	73,430
1.7	4,759	11,447	17,547	20,350	21,829	23,361	26,579	33,639	45,787	59,803	75,689
1.8	4,897	11,779	18,055	20,940	22,462	24,038	27,350	34,615	47,115	61,538	77,883
1.9	5,031	12,101	18,550	21,514	23,077	24,697	28,098	35,562	48,404	63,221	80,015
2.0	5,162	12,416	19,032	22,072	23,678	25,338	28,830	36,488	49,664	64,868	82,098

[1]Based on standard air conditions (70 °F, 29.92 inches Hg) and 1 center-of-the-pipe pitot tube reading (4,005 x 0.9113 = 3,650).
[2]Velocity (ft/min) = 3,650 x velocity pressure (inches $H_2O)^{0.5}$.
[3]Volume of air (ft^3/min) = velocity (ft/min) x area of pipe (ft^2).

Table 6–4.
Area and circumference of round pipe

Diameter (inches)	Area[1] (inches^2)	Area[1] (ft^2)	Circumference[2] (inches)
8	50.27	.349	25.13
9	63.60	.442	28.27
10	78.50	.545	31.42
11	95.00	.660	34.56
12	113.10	.785	37.70
13	132.70	.922	40.84
14	153.90	1.069	43.98
15	176.70	1.227	47.12
16	201.00	1.396	50.26
17	226.90	1.576	53.41
18	254.40	1.767	56.55
19	283.50	1.969	59.69
20	314.10	2.182	62.83
21	346.30	2.405	65.97
22	380.10	2.640	69.11
23	415.40	2.885	72.26
24	452.30	3.142	75.40
25	490.80	3.409	78.54
26	530.90	3.687	81.68
27	572.50	3.976	84.82
28	615.70	4.276	87.96
29	660.50	4.587	91.11
30	706.80	4.909	94.25
31	754.70	5.241	97.39
32	804.20	5.585	100.53
33	855.30	5.940	103.67
34	907.90	6.305	106.81
35	962.10	6.681	109.96
36	1,017.80	7.069	113.10
37	1,075.20	7.467	116.24
38	1,134.10	7.876	119.38
39	1,194.50	8.296	122.52
40	1,256.60	8.727	125.66
42	1,385.44	9.621	131.95
44	1,520.53	10.559	138.23
46	1,661.90	11.541	144.51
48	1,809.56	12.566	150.80
50	1,963.50	13.635	157.08
52	2,123.72	14.748	163.36
54	2,290.22	15.904	169.65

[1]Area = 0.7854 x diameter^2.
[2]Circumference = 3.14 x diameter.

Table 6–5.
Air velocity and air volume correction factors for nonstandard air conditions

Temperature (°F)	Correction factor	Altitude[1]	Correction factor
0	0.932	0[2]	1.000
20	.952	500	1.009
40	.971	1,000	1.018
60	.990	1,500	1.028
70[3]	1.000	2,000	1.037
80	1.009	2,500	1.046
100	1.028	3,000	1.056
120	1.046	3,500	1.066
140	1.064	4,000	1.075
160	1.082	4,500	1.086
180	1.098	5,000	1.095
200	1.114	5,500	1.106
225	1.137		
250	1.157		
275	1.177		
300	1.197		
350	1.236		
400	1.273		
450	1.310		
500	1.345		

[1]Feet above mean sea level.
[2]Sea level. Standard condition.
[3]Standard condition.

ft^3/min) for any given Pv and for various commonly used pipe diameters. The volume for other pipe sizes can be calculated by the equations given in the footnotes of the tables. Pipe areas are given in table 6–4.

The following example demonstrates the proper use of table 6–2. If a fan produces a Pv reading of 1.6 inches of water in a 13-inch diameter pipe, table 6–2 can be used to estimate that the associated air velocity in the pipe is 4,617 ft/min and the associated air volume is 4,256 ft^3/min. Since table 6–2 is based on standard air conditions, an air density correction factor must be considered if the fan handles air at other than standard temperature and altitude. Correction factors for temperature and altitude variations are given in table 6–5. If the fan is handling air at 200 °F and is located at an altitude of 3,000 ft above sea level, the correction factors for temperature and altitude are 1.114 and 1.056, respectively. The composite correction factor is 1.114 x 1.056 = 1.176. The corrected velocity is 4,617 x 1.176 = 5,430 ft/min. The corrected volume is 4,256 x 1.176 = 5,005 ft^3/min.

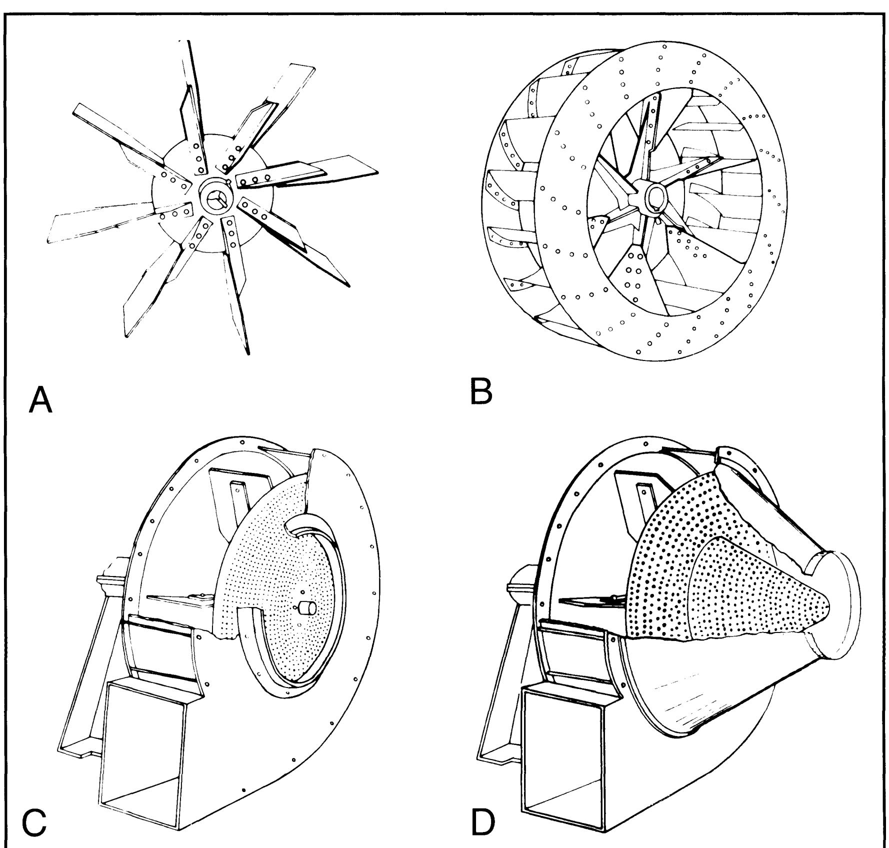
Centrifugal Fans

Two types of fans, centrifugal and axial flow, are in common use in cotton gins, but the majority are centrifugal fans. The centrifugal fan consists of a bladed wheel that rotates within a cast-iron or sheet metal housing (fig. 6–2). The fan housings usually used in ginning applications have a single air inlet and a single outlet. Size designations are confusing because manufacturers use their own descriptive terms. Many fans, however, are designated simply by size from No. 20 to No. 70 or from F–76 to F–238.

Rembert fans (fig. 6–2, C and D) with perforated flat disks or cones permit the material to pass through the fan housing without damage from the wheel. This type of fan can be used for transferring seed cotton from one location to another (such as from a trailer to a storage place) without using a separator. Rembert-type fans are normally only about 35-percent efficient.

Normal operating speeds of centrifugal fans vary usually from 1,200–3,000 rpm, but for safety the tip speed (wheel circumference [in feet] times rpm) of the wheel should not exceed manufacturer's recommendations. The maximum safe speed for many fans used in the gin is 18,000 ft/min. Since the wheel diameter is not always known when changing the speed of a fan, it is a

Figure 6–2. Representative types of centrifugal fan wheels. *A*, Plain eight-blade wheel; *B*, Shrouded multiblade wheel; *C*, Rembert-type wheel in casing; and *D*, Rembert-type cone wheel.



good practice to contact the manufacturer and request specific information on the fan in question. If it becomes necessary to speed up fans, resulting changes in performance may be calculated from the following basic fan laws:

1. Capacity (in ft^3/min) varies directly with the speed (in rpm).

2. Static pressure (in inches of water) varies as the square of the speed.

3. Power (in hp) required varies as the cube of the speed.
   These laws are expressed in the following formulas:

$$\frac{\text{Original capacity}}{\text{Final capacity}} = \frac{\text{Original speed}}{\text{Final speed}} \qquad [6.1]$$

$$\frac{\text{Original pressure}}{\text{Final pressure}} = \frac{\text{Original speed squared}}{\text{Final speed squared}} \qquad [6.2]$$

$$\frac{\text{Original horsepower}}{\text{Final horsepower}} = \frac{\text{Original speed cubed}}{\text{Final speed cubed}} \qquad [6.3]$$

As long as the voltage and frequency remain constant, motor current (in amps) can be substituted for horsepower in equation 6.3 with only a slight error. Amps are more convenient for ginners to use, since motor current is easier to measure than actual horsepower. The results will be accurate enough for field calculations.

Many ginners do not understand the effects of fan speed. If fan speed is doubled, the capacity is also doubled; but the resistance pressure is four times as great and the horsepower consumed is eight times as great. Assume, for example, that a fan operating at 1,100 rpm and delivering an air volume of 2,500 ft^3/min against a static pressure of 6 inches of water is using 5 hp. If the speed is doubled to 2,200 rpm and the temperature and altitude remain the same, the volume of airflow will be doubled to 5,000 ft^3/min, the static pressure will be increased to 24 inches of water, and the power consumed will increase to 40 hp.

Care should be taken to choose a fan that will meet the needs of the ginner when the fan is operated within speed and capacity ranges recommended by the manufacturer. Table 6–6 can be used as a general guide for selecting gin fans. However, the most accurate information available on fan performance is that contained in certified performance tables provided by manufacturers. To obtain maximum efficiency from a fan, it is essential that the fan application be designed from accurate rating tables. Centrifugal fans vary widely in efficiency because of basic differences in design and construction and in how they are utilized in an air handling system. The efficiency of centrifugal fans can vary from 35–75 percent as a result of these differences.

When two fans are placed parallel to each other, the air volume is doubled, but the static pressure remains the same; however, if they are placed in series, the air volume remains the same and the static pressure is doubled.

Table 6–6.
Typical operating parameters for fans handling air at standard conditions

Fan size or equivalent	Wheel diameter (inches)	Capacity range (ft^3/min)	Speed range[1] (rpm)	Static pressure[2] Straight-blade (inches H_2O)	Static pressure[2] Multiblade (inches H_2O)
Single 20	18	1,250 to 1,750	2,200 to 3,000	Up to 14	Up to 17
Single 25	22	1,500 to 2,000	1,800 to 2,800	Up to 16	Up to 19
Single 30	20-7/16	2,000 to 3,000	2,000 to 3,000	Up to 18	Up to 21
Single 35	23-1/16	3,000 to 4,000	2,000 to 2,600	Up to 18	Up to 21
Single 40	26-11/16	4,000 to 5,000	1,800 to 2,400	Up to 22	Up to 24
Single 45	30	5,000 to 6,000	1,600 to 2,200	Up to 23	Up to 25
Single 50	33	6,000 to 8,000	1,400 to 2,000	Up to 22	Up to 25
Single 60	40-1/4	10,000 to 15,000	1,200 to 1,600	Up to 19	——
Single 70	49	15,000 to 20,000	1,100 to 1,400	Up to 17	——
Parallel 40	——	8,000 to 10,000	1,800 to 2,400	Up to 22	Up to 24
Parallel 45	——	10,000 to 12,000	1,600 to 2,200	Up to 23	Up to 25
Parallel 50	——	12,000 to 16,000	1,400 to 2,000	Up to 22	Up to 25
Parallel 60	——	20,000 to 30,000	1,200 to 1,600	Up to 19	——
Parallel 70	——	30,000 to 40,000	1,100 to 1,400	Up to 17	——
Series 40	——	4,000 to 5,000	1,800 to 2,400	Up to 44	Up to 48
Series 45	——	5,000 to 7,000	1,600 to 2,200	Up to 46	Up to 50
Series 50	——	6,000 to 8,000	1,400 to 2,000	Up to 44	Up to 50
Series 60	——	10,000 to 15,000	1,200 to 1,600	Up to 38	——
Series 70	——	15,000 to 20,000	1,100 to 1,400	Up to 34	——

[1]See manufacturer recommended speeds. Tip velocity for many fans should not exceed 18,000 ft/min; tip velocity = rpm x circumference.
[2]Fan intake plus discharge static pressure. These values will vary slightly with manufacturer and number of blades on wheel.

Large-diameter fan wheels operating at low speeds are generally more efficient and produce less noise than small-diameter fan wheels at high speeds.

Most manufacturers base fan performance ratings on handling air at standard conditions (air having a temperature of 70 °F and having a barometric pressure of 29.92 inches of mercury and weighing 0.075 lb/ft^3). Correction factors for adjusting required fan pressure and horsepower for variations in temperature and altitude are given in table 6–7. The following example demonstrates the proper use of table 6–7:

EXAMPLE: The fan performance curves shown in figure 6–3 describe the performance of a size 40 gin fan when operated at standard conditions (sea level and 70 °F). When the fan, for example, is operated at a speed of 2,000 rpm it delivers 4,500 ft^3/min of air against a system static pressure of 14.4 inches of water. The required horsepower under these conditions is 22 hp. Suppose, however, one wants to operate the fan at an altitude of 2,500 ft to

Table 6–7.
Correction factors for adjusting estimated pressure and horsepower requirements of fans operating at nonstandard conditions

Temperature (°F)	Factor	Altitude[1]	Factor
0	0.87	0[2]	1.00
20	.91	500	1.02
40	.94	1,000	1.04
60	.98	1,500	1.06
70[3]	1.00	2,000	1.08
80	1.02	2,500	1.10
100	1.06	3,000	1.12
120	1.09	3,500	1.14
140	1.13	4,000	1.16
160	1.17	4,500	1.18
180	1.21	5,000	1.20
200	1.25	5,500	1.22
225	1.29		
250	1.34		
275	1.39		
300	1.43		
350	1.53		
400	1.62		
450	1.72		
500	1.81		

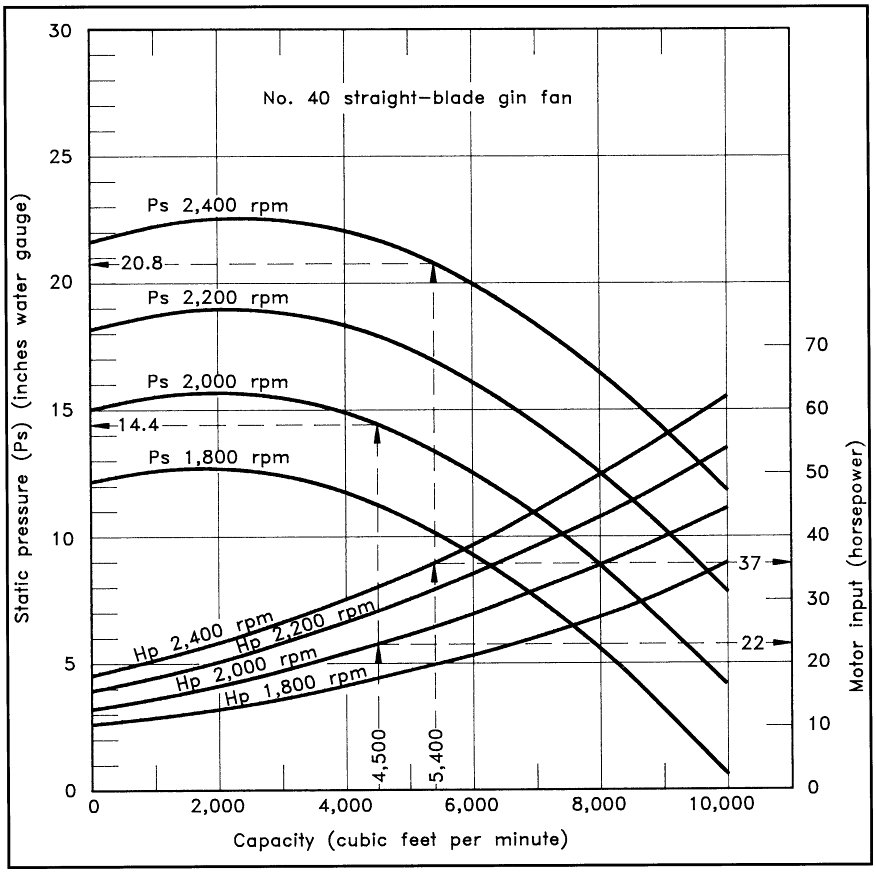
[1]Feet above mean sea level.
[2]Sea level. Standard condition.
[3]Standard condition.

handle air that has been heated to 140 °F. What are the performance characteristics of the fan under the new operating conditions (assuming the fan speed remains the same)?

SOLUTION: Since the fan speed was not changed, the fan will continue to deliver 4,500 ft^3/min of air. This air, however, will be less dense than standard air because of the higher temperature and altitude. This change in density will affect static pressure and the horsepower requirement. From table 6–7 we find that the correction factors for temperature and altitude are 1.13 and 1.10, respectively. The composite correction factor is $1.13 \times 1.10 = 1.24$. At the new operating condition the static pressure is $14.4 \div 1.24 = 11.6$ inches of water and the horsepower required is $22 \div 1.24 = 17.7$ hp.

The performance characteristic curves of a fan provide a good means of determining its capabilities; the performance of fans that are the same size

Figure 6–3. Typical performance characteristic curves for a No. 40 straight-blade fan



but that are made by different manufacturers will be slightly different. If the fan capacity and speed are known, the Ps and hp can be determined from the fan curves. As shown in the previous example, if the capacity is 4,500 ft^3/min and the speed is 2,000 rpm, then the fan requires 22 hp and develops a Ps of 14.4 inches of water (see fig. 6–3).

If you wish to increase the volume of air to 5,400 ft^3/min, the necessary speed of the fan can be determined from equation 6.1 as follows:

$$\frac{\text{Original capacity}}{\text{Final capacity}} = \frac{\text{Original speed}}{\text{Final speed}}$$

$$\frac{4{,}500}{5{,}400} = \frac{2{,}000}{\text{Final speed}}$$

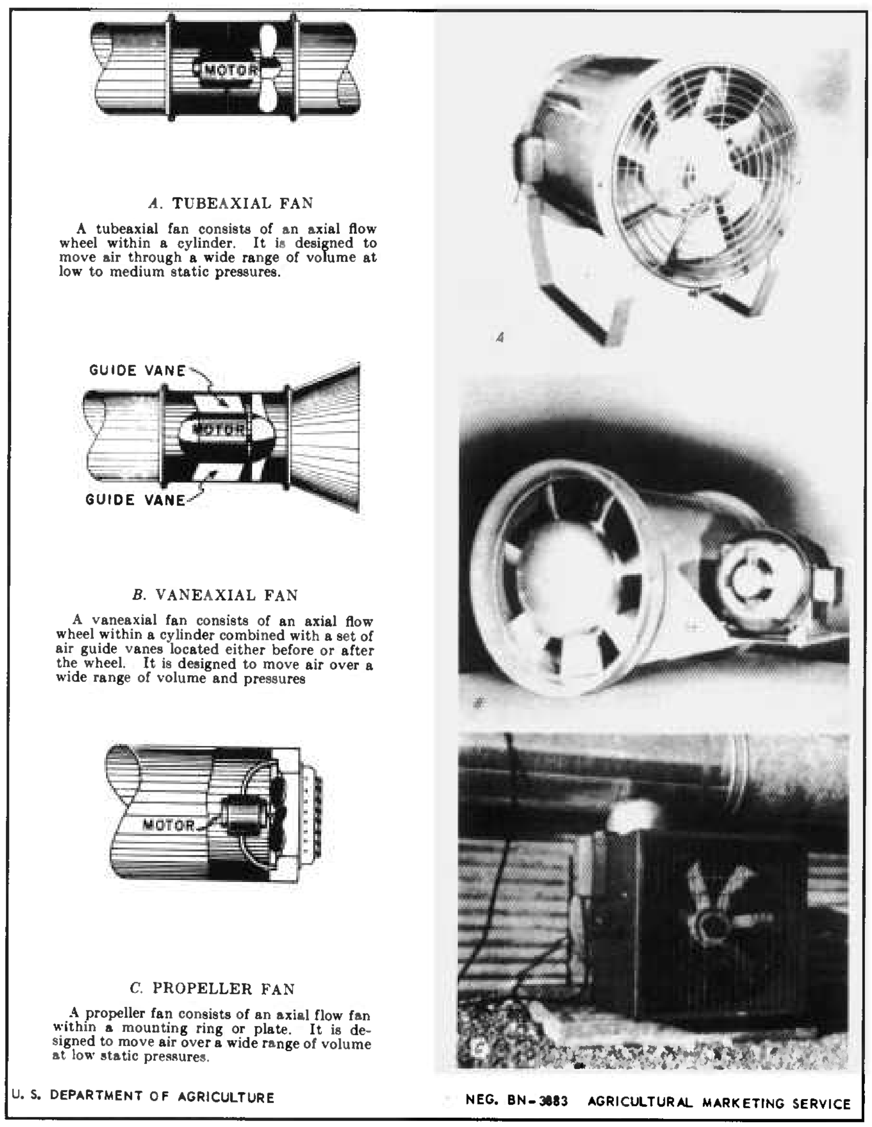
Final speed = 2,400 rpm.

The new horsepower requirements (37 hp) and the new static pressure (20.8 inches of water) can now be determined from the performance curves in figure 6–3. If fan performance curves are not available but the original speed, the static pressure, the volume of air flow, and the motor current are known, the new requirements can be calculated by using equations 6.1, 6.2, and 6.3.

Axial-Flow Fans

Axial-flow fans include those fans that move air by a thrust effect of the inclined blades. The air enters axially at the leading edge of the blade, and the flow is essentially parallel to the impeller shaft. In addition, the air rotates about the shaft axis. Fans in this category are usually classified as tubeaxial, vaneaxial, or disk (also called propeller) (fig. 6–4). Propeller fans are rarely used in cotton gins.

Figure 6–4. Three types of axial-flow fans (USDA, Agricultural Marketing Service, PN–5241)



A tubeaxial fan consists of a relatively large hub with helical blades rotating within a cylinder and will operate against resistance pressures of 2–3 inches of water. These fans are sometimes referred to in the ginning industry as clean-air or duct fans.

Vaneaxial fans consist of an axial-flow impeller within a cylinder that contains a set of guide vanes located either before or after the impeller. These guide vanes assist in recovering the energy used for tangential acceleration, and therefore fans of this design are capable of operating against static pressures of up to 6 or 7 inches of water.

Axial-flow fans are sized by the diameter of the cylinder housing. The basic fan laws, which were discussed in connection with centrifugal fans, also apply to these fans. Performance curves can be used in the same manner as for centrifugal fans.

One of the distinguishing characteristics of axial-flow fans is that they generally require more horsepower as the flow rate decreases, with the horsepower requirement being maximum when flow stops. The opposite is true for centrifugal fans, which require minimum horsepower when flow stops.

Unlike centrifugal fans, axial-flow fans cannot handle material through the fan impeller. They are primarily used in low-pressure machinery, such as lint-cleaner condensers and battery condensers. An access door should be provided on both sides of the fan to facilitate inspection for lint fly buildup, especially on the fixed vanes.

Separators and Droppers

Separators are machines designed to do just what their name implies—to separate seed cotton from the conveying air in a pneumatic conveying system (Wright 1977). In addition to this primary function, separators also remove limited quantities of dust and fine trash from the seed cotton. Separators are used at various locations in the ginning plant. They are used in the unloading system to handle the incoming seed cotton and are used over the conveyor distributor to handle seed cotton recycled from the overflow bin or hopper. Some ginners also use separators to feed cotton into other machines (cylinder cleaners and stick machines) in the gin's seed cotton cleaning system. Separators are vital links in a gin's materials handling system and must be properly maintained to ensure trouble-free processing. A separator used in the unloading system generally requires more maintenance than one used at other locations. Uneven material flow, high negative pressures, and high trash levels in the unloading system create especially severe operating conditions for a separator.

Separators presently manufactured are of four basic types:

1. Those in which the main flow of seed cotton does not come in contact with a stationary screen; the screen of this type is cleaned by rubber

wiper flights attached to a revolving reel or cleaner-type cylinder (figs. 6–5 and 6–6)

2. Those in which the seed cotton is directed onto a stationary screen, which is kept clean by rubber wiper flashing attached to a revolving reel (fig. 6–7)

3. Those in which the seed cotton is directed over and around a revolving screen drum, which is kept clean by the centrifugal force of the rotating drum (fig. 6–8)

4. Those in which the seed cotton is directed diagonally onto a stationary grid-bar screen, which is cleaned by the wiping action of the incoming seed cotton and air (fig. 6–9).

The wipers of the first two types of separators require little maintenance unless the wipers are subjected to high temperature, as is the case when the separator is used as the receiving unit in the drying system. However, the wipers should be inspected periodically for wear and damage. Each wiper has slotted fastening holes and can be adjusted to the screen as wear occurs. The wipers should be set so that they lightly wipe the surface of the screen. If the wipers have become set in a cupped position away from the screen, they can sometimes be removed and turned over to give further service. Excessively worn and broken wipers should be replaced.

The upper section of the third type of separator requires little maintenance other than periodic inspection of the seal flashing to see if it is sealing the ends of the screen drum properly. Worn and damaged flashing should be replaced.

The upper section of the fourth type of separator requires periodic inspection to see if the grid-bar section is being properly cleaned by the wiping action of the incoming seed cotton and air. Spread of seed cotton over the entire width of the screen is important and is obtained by adjusting a dovetail spreader in the inlet transition. The grid-bar screen should be adjusted so that the ends of the grid bars clear the back baffle by about 2 inches.

The lower, or vacuum dropper, section of all separators is a very important part of the overall unit. The purpose of the vacuum dropper is to provide an air seal for the upper section while allowing the discharge of seed cotton from the pressurized air handling system. The rubber flights in the vacuum dropper require more attention and more frequent adjustment or replacement than do the rubber wipers in the upper screen section of the separator. To minimize air leakage into or out of the separator, these flights must be maintained in proper adjustment and good condition. When separator choking occurs, it is usually because the flights have become so worn or damaged that they are not sealing properly against the side scrolls. Once the seal is destroyed, the air leakage passing the flights may cause an updraft of sufficient force to float the seed cotton in the upper section and prevent it from discharging through the vacuum section.

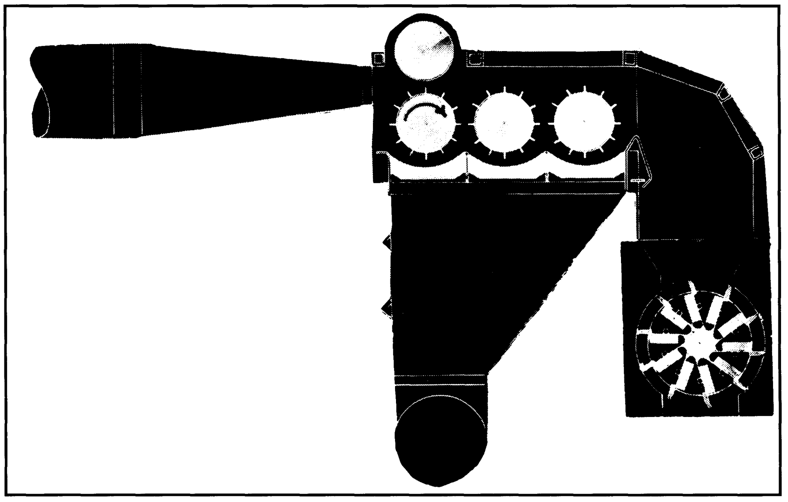


Figure 6–5. Separator with multiple screen sections and cylinders (courtesy of Continental Eagle Corporation)

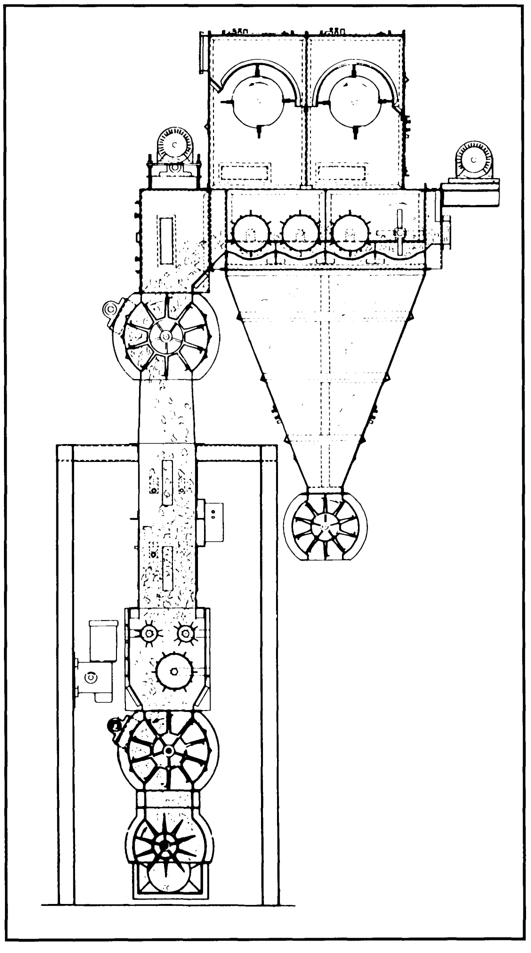


Figure 6–6. Combination separator and cleaner mounted above a feed control (courtesy of Consolidated Cotton Gin Co., Inc.)

Figure 6–7. Separator with curved screen and revolving reel (courtesy of Corporation)

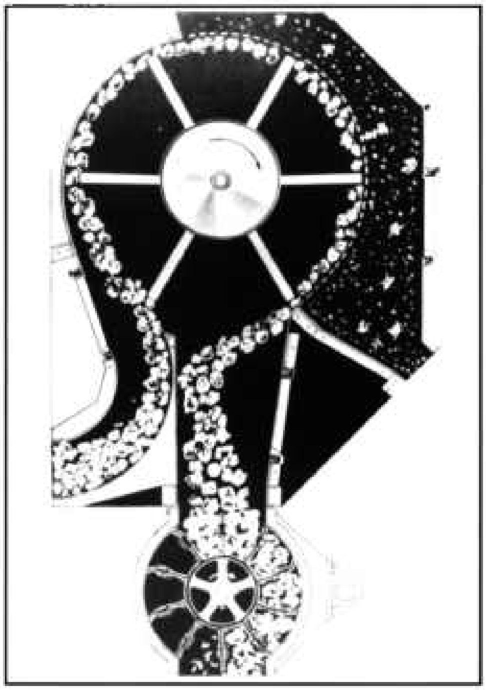


Figure 6–8. Separator with revolving screen drum (courtesy of Continental Eagle Corporation)

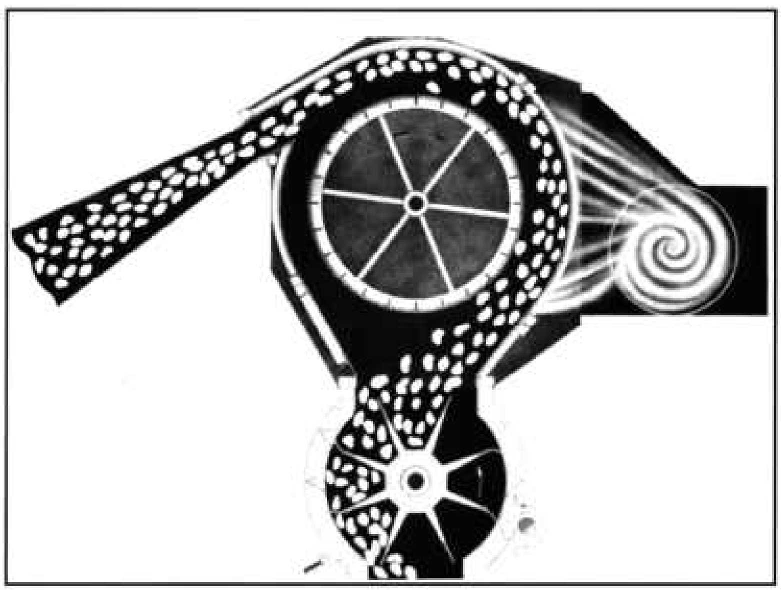
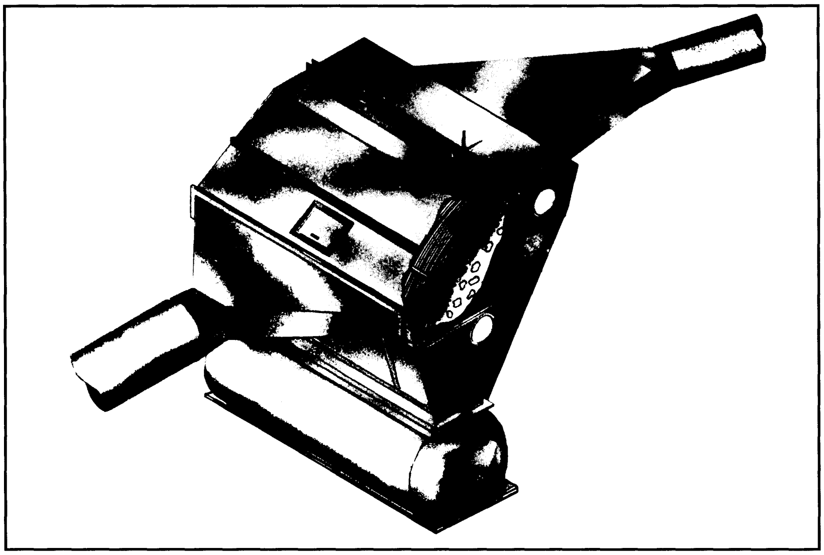


Figure 6–9. Separator with curved grid-bar screen (courtesy of Kimbell Gin Machinery Company)



In addition, vacuum droppers (also known as vacuum wheels) are used in various other locations throughout the gin plant to meter seed cotton, cottonseed, and trash into a conveying airstream. They are used in or in conjunction with other pressurized machines, such as airfed inclined cleaners, to seal the machines while cotton or other material is discharged from the machines.

A typical seed cotton dropper is shown in figure 6–10; most droppers have construction and maintenance requirements that are identical to those of the lower or vacuum section of the separator. When adjusting or installing flights, the manufacturer's instructions should be followed carefully. Generally, flights should be set so that the edges rub securely against the side scrolls. When the flights pass the side scroll, they should bend approximately one-half inch and not more than three-fourths of an inch from a straight line. They should not be required to bend or flex unduly. When the rubber flights are checked or replaced, the rubber flashings or wipers on the ends of the vacuum wheel should also be inspected and then replaced if they are damaged or worn. Some models of droppers have quick-change rubber flights that make repair and maintenance quick and easy. Some drying systems incorporate a deflector dropper, commonly called a flight-saver, between the seed cotton dropper and the hot-air stream. The flight-saver deflects most of the hot air away from the seed cotton dropper, lengthening the life of the rubber flights. Seed cotton droppers used in the drying system should be equipped with heat-resistant flights.

Trash droppers and seed droppers are smaller in diameter and length than seed cotton droppers. The typical trash dropper (fig. 6–11) has the same basic design as the seed dropper (fig. 6–12); the main difference is that the seed dropper has more flights than the trash dropper. The additional flights are necessary to obtain sufficient sealing power for feeding into high-pressure seed lines. Trash and seed are very abrasive, and the flights in trash

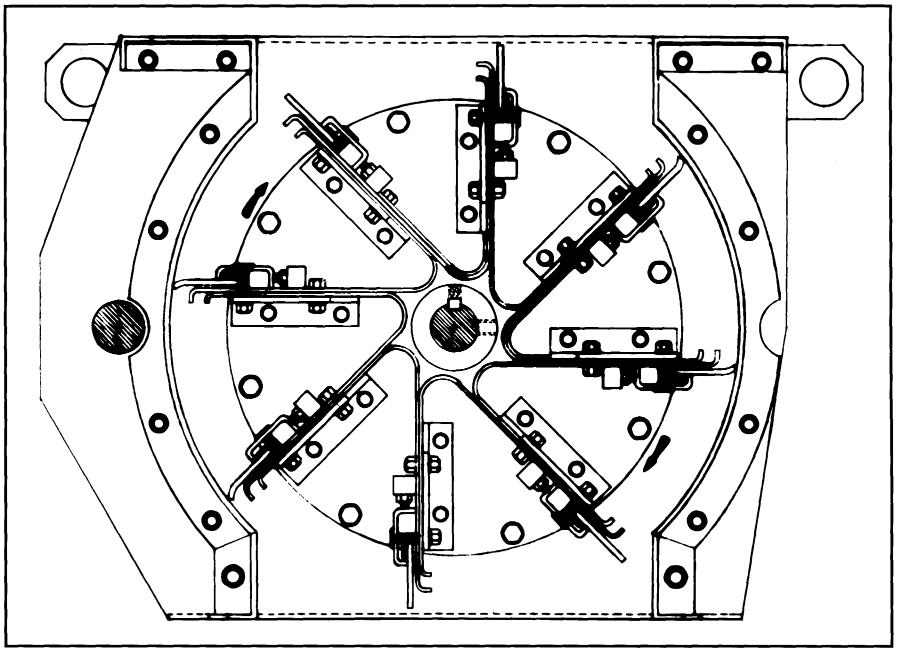


Figure 6–10. Seed cotton vacuum-wheel dropper

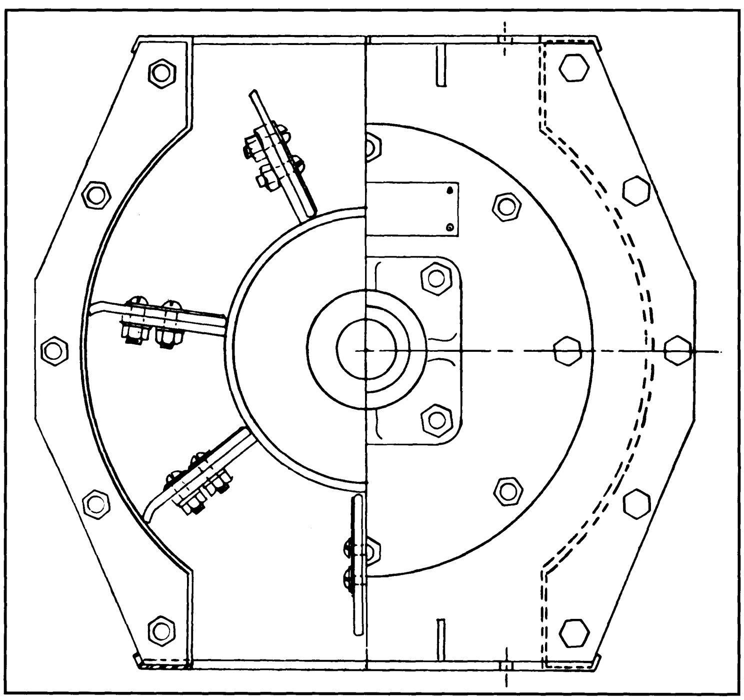


Figure 6–11. Trash vacuum-wheel dropper

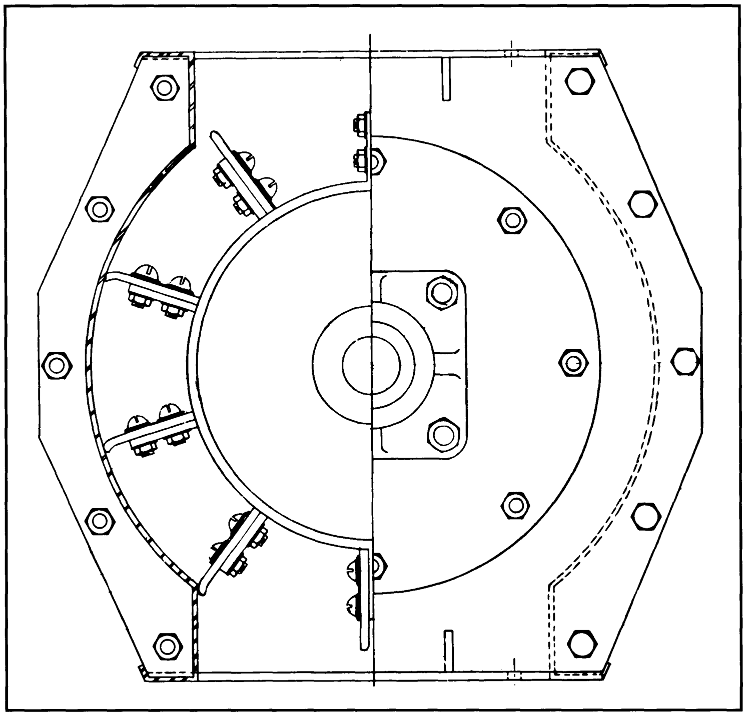


Figure 6–12. Cottonseed vacuum-wheel dropper

and seed droppers require more frequent inspection and maintenance than those in seed cotton droppers.

Capacity and power requirements for various sizes of separators and droppers are given in table 6–8. These data are averages and will vary considerably for different types of cotton. The manufacturer should always be consulted in making capacity and power estimates for separators and droppers.

Separators and droppers used in gin pneumatic systems may waste a lot of power. Continuous upkeep, inspection, and repair are necessary to reduce air leakage. Even new and well-sealed separators have a significant intake and leakage of air through the vacuum dropper section; a 35-percent loss at the separator is not uncommon. A periodic check of all separators and droppers will greatly reduce downtime from chokages caused by improper settings or worn parts in the separator or dropper.

Blowboxes

The sheet metal connection between a vacuum dropper and an air conveying line is generally known as a blowbox. If the conveying air is moving parallel to the shaft of the vacuum dropper, this connection is referred to as a "parallel-flow" blowbox. Conversely, in a "cross-flow" blowbox the conveying air moves at right angles to the shaft of the vacuum dropper.

The air velocity in either type of blowbox is critical. If the velocity is too low, the feed material will not be properly accelerated to the required conveying velocity and may accumulate in the bottom of the blowbox. This condition

Table 6–8.
Capacities and power requirements for various sizes of separators and droppers

Size and manufacturer	Dropper diameter (inches)	Rated capacity	Power required (hp)	Dropper speed (rpm)
Seed cotton separators				
Consolidated[1]:				
72-inch 4-cylinder unit	30	16–24 bale/hr	[2]30	[3]31
96-inch 4-cylinder unit	30	20–36 bale/hr	[2]30	[3]31
Continental Murray[4]:				
50-inch revolving drum	24	8–13 bale/hr	5	[5]68
72-inch revolving drum	24	12–18 bale/hr	7.5	[5]68
72-inch 3-cylinder unit	24	15–20 bale/hr	[2]25	[6]69
96-inch 3-cylinder unit	24	24–40 bale/hr	[2]30	[6]69
Lummus Corporation[7]:				
72-inch revolving reel	22.5	8–16 bale/hr	[8]15	[9]65–70
72-inch revolving reel	34	16–24 bale/hr	20	[9]65–70
96-inch revolving reel	34	24–35 bale/hr	25	[9]65–70
Vacuum droppers				
Consolidated[1]:				
72-inch seed cotton	30	16–24 bale/hr	10	31
96-inch seed cotton	30	20–36 bale/hr	10	31
120-inch seed cotton	30	25–38 bale/hr	15	31
24-inch cottonseed	24	620 lb/min	3	10.5
30-inch cottonseed	24	650 lb/min	5	10.5
30-inch cottonseed	36	990 lb/min	5	10.5
24-inch trash	24	750 lb/min	3	41
Continental:				
72-inch seed cotton	24	12–18 bale/hr	7.5	63–70
96-inch seed cotton	24	16–30 bale/hr	7.5	63–70
120-inch seed cotton	24	20–35 bale/hr	10	70–76
96-inch seed cotton	36	36–60 bale/hr	15	70
120-inch seed cotton	36	over 60 bale/hr	20	70
18-inch cottonseed	12	1110 lb/min	5	68–75
24-inch trash	12	285 lb/min	3	59–71
24-inch trash	18	360 lb/min	5	56
24-inch trash	24	650 lb/min	10	65–75
30-inch trash	30	850 lb/min	10	41
Lummus Corporation[7]:				
72-inch seed cotton	22.5	8–16 bale/hr	10	65–70
72-inch seed cotton	34	16–24 bale/hr	15	65–70
96-inch seed cotton	34	24–35 bale/hr	20	65–70
12-inch cottonseed	16	235 lb/min	1	50–55
18-inch cottonseed	16	352 lb/min	2	50–55
24-inch cottonseed	16	470 lb/min	3	50–55
12-inch trash	16	120 lb/min	1	50–55
18-inch trash	16	180 lb/min	2	50–55
24-inch trash	16	240 lb/min	3	50–55

[1]Consolidated Cotton Gin Co., Lubbock, TX.
[2]Total horsepower requirements for cleaning cylinders and dropper.
[3]Separator reel and cleaning cylinders operate at 51 and 455 rpm, respectively.
[4]Continental Eagle Corporation, Prattville, AL.
[5]Separator drum operates at 115 rpm.
[6]Cleaning cylinders operate at 611 rpm.
[7]Lummus Corporation, Columbus, GA.
[8]When used as overflow separator or for capacities below 8 bale/hr, only 10-hp motor required.
[9]Separator reel operates at 125 rpm.

will produce uneven, sluggish flow and greatly increase the chances of choking the blowbox or some other machine downstream from the blowbox. The blowbox should be sized to produce an air velocity that is at least as great as that recommended for normal conveying (see information on piping in this section on page 145). For more severe conditions, such as the handling of wet cotton at high feed rates, it is advisable to increase these recommended velocities by 30–40 percent in the blowbox.

In addition to introducing cotton into a conveying airstream, specially designed blowboxes can be used to open single-lock seed cotton for more effective drying and cleaning. A high-velocity, cross-flow blowbox (fig. 6–13) has been recently developed for this purpose and successfully utilized in both upland and long-staple cotton gins. In this version of a blowbox, seed cotton is impacted by an extremely high-velocity stream of air that tends to separate and open compacted clumps of seed cotton that often exist at the discharge of a vacuum dropper. Inlet air velocities in the range of 12,000–20,000 ft/min are normally used in this type of blowbox. Because of the extremely high velocities generated in the special blowbox, care must be taken in the design of the downstream piping to prevent cottonseed damage. Appropriate expansion or transition sections should be used to reduce the air velocity down to that recommended for conveying before the cotton reaches an elbow or other impact point.

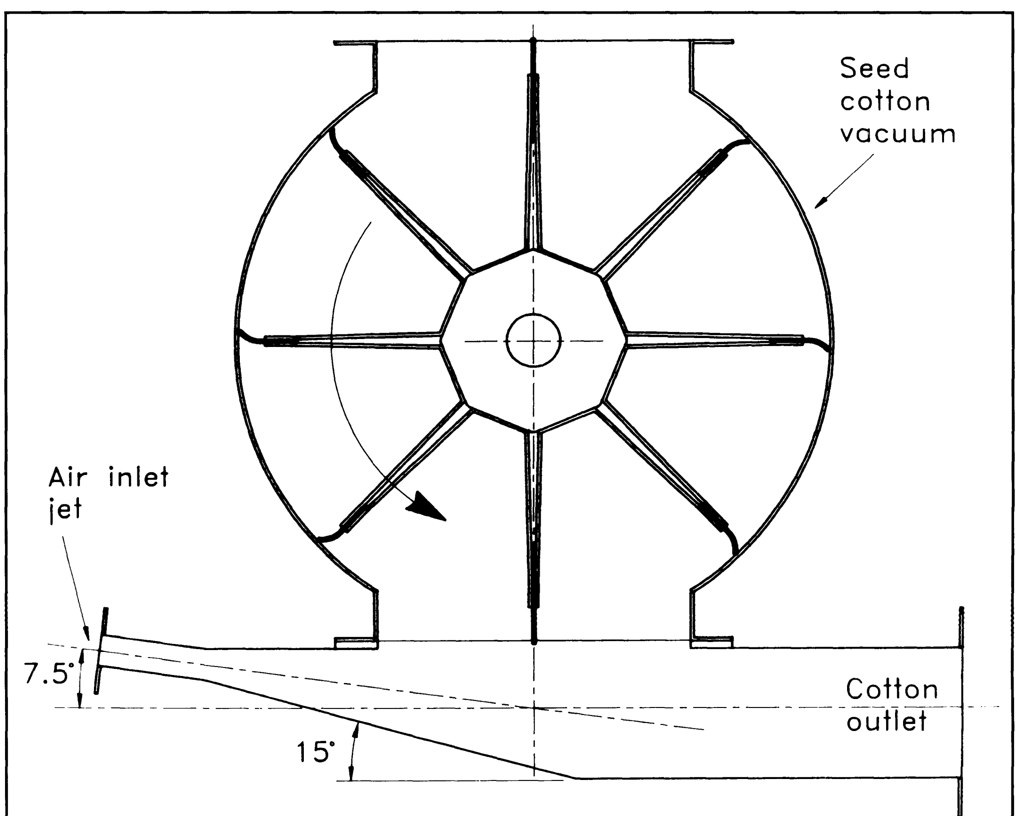


Figure 6–13. High-speed, cross-flow blowbox (courtesy of Eckley Engineering)

The air velocity in a blowbox is determined by the total airflow and the cross-sectional area of the blowbox. When a section of rectangular duct is added between the vacuum dropper and the blowbox, the cross-sectional area for airflow is effectively increased. This increase in area produces a proportional decrease in air velocity. As a result, an increased airflow will be required to properly accelerate the feed material to the required conveying velocity. To save unnecessary airflow, and therefore unnecessary expense, a blowbox should be attached directly to the discharge flange of a vacuum dropper. Although this is an important consideration for all blowbox designs, the problems created by duct sections are more pronounced with the parallel-flow design.

Mechanical Conveyors

The types of mechanical conveyors normally used in cotton gins include belt conveyors and screw conveyors (Alberson 1977). Although belt conveyors are sometimes used to convey seed cotton and trash, their primary use is for conveying cottonseed from under the gin stands to a vacuum dropper discharging into a pneumatic conveying line. Because a belt conveyor is self-cleaning, the ginner can keep different varieties of seed separated with minimal effort. The belt conveyor is a relatively simple device that is easy to repair and maintain. Since it provides a high carrying capacity with minimum use of power, it is a very inexpensive method of conveying. Also, when properly designed and maintained, a belt conveyor has a long service life.

Most seed conveying belts used at cotton gins operate inside a metal trough. This arrangement reduces loss of seed and increases the handling capacity of the conveyor belt. Seed should be loaded onto the center of the belt to avoid problems associated with seed getting under the edges of the belt. The approximate conveying capacity of a trough-type seed belt can be determined as follows:

Capacity (in tons/hr) = WDS/320, [6.4]

where

W = belt width (in inches),
D = trough depth (in inches), and
S = belt speed (in ft/min).

This equation assumes a 50 percent loading factor for the belt and a cottonseed bulk density of 30 lb/ft^3.

The motor horsepower required to operate a seed belt can be estimated using the following equation:

Horsepower = CFLS/33,000E, [6.5]

where

C = coefficient of friction for a flat belt on a metal trough (0.89 for worst-case condition),
F = force from weight of belt and seed on trough (in lb/ft),
L = belt length (in ft),
S = belt speed (in ft/min), and
E = efficiency of drive system (normally about 0.8).

EXAMPLE: Calculate the capacity and horsepower requirements for a seed conveying belt that is 100 ft long by 10 inches wide and is operating at a speed of 100 ft/min inside a trough that is 6 inches deep. Assume that the belt weighs 2 lb/ft and that the seed bulk density is 30 lb/ft^3.

SOLUTION:

Capacity = (10)(6)(100)/320 = 6000/320 = 18.75 tons/hr

Weight of seed per foot = (tons/hr)(2000)/(60S)
= (18.75)(2000)/(60 $\times$ 100)
= 6.25 lb/ft

Force (F) on trough = belt weight + seed weight
= 2 + 6.25 = 8.25 lb/ft

Horsepower = (0.89)(8.25)(100)(100)/(33,000)(0.8)
= 2.78 hp [use 3 hp motor].

Screw conveyors are frequently used in cotton gins to convey seed cotton, cottonseed, and trash. Even though screw conveyors require more power than belt conveyors, screw conveyors are simple in design and relatively inexpensive to operate. The standard-pitch screw has a pitch approximately equal to its diameter. The standard screw is used on most horizontal installations and on inclines up to 20°. Most horizontal screw conveyors are operated in U-shaped troughs and have the screws supported by bearings at various standard intervals.

The conveying capacity of various sizes of screw conveyors can be determined by referring to the chart in table 6–9. This table gives the capacity in terms of ft^3/hr. The total weight of material conveyed per hour can be determined by multiplying the capacity (in ft^3/hr) by the bulk density of the conveyed material (4–6 lb/ft^3 for seed cotton, 10–12 lb/ft^3 for trash, and 25–30 lb/ft^3 for cottonseed).

The horsepower requirements of screw conveyors are a function of a number of factors, which are discussed in considerable detail in the design sections of most manufacturer's literature (Screw Conveyor Corporation 1987). A full discussion of these variables is too lengthy for inclusion in this book. However, for illustrative purposes the following equation and example are presented for a specific ginning application:

Horsepower = 11L(BN + KDM)/9,000,000, [6.6]

where

L = conveyor length (in ft),
B = ball bearing factor (this factor is 32, 55, 78, 106, and 140 for screws having a diameter of 9, 12, 14, 16, and 18 inches, respectively),
N = speed of screw (in rpm),
K = conveying capacity (ft^3/hr),
D = bulk density of material (in lb/ft^3), and
M = material factor (0.9 for cottonseed, 1.5 for trash).

EXAMPLE: Determine the conveyor size and horsepower needed to convey cottonseed a horizontal distance of 100 ft at a rate of 37,500 lb/hr. Assume that the seed has a bulk density of 30 lb/ft^3.

SOLUTION:

1. Determine the required conveying capacity (in ft^3/hr) as follows:
   Capacity = lb of material conveyed per hour ÷ bulk density = 37,500 ÷ 30 = 1,250 ft^3/hr.

2. Refer to table 6–9 and locate a screw size that will handle a capacity of 1,250 ft^3/hr. The smallest screw that will handle this capacity is the 14-inch diameter screw, which has a design capacity of 20.8 ft^3/hr at 1 rpm.

3. Determine the required screw speed as follows:
   Speed = capacity ÷ design capacity at 1 rpm = 1,250 ÷ 20.8 = 60 rpm.

4. Calculate hp by using equation 6.6:
   Horsepower = 11(100)[(78)(60) + (1,250)(30)(.9)] ÷9,000,000 = 4.7 hp [use 5 hp motor].

Table 6–9.
Maximum speed and capacity of horizontal screw conveyors

Screw diameter (inches)	Maximum speed (rpm)	Conveying capacity at 1 rpm[1] (ft^3/hr)	Maximum capacity (ft^3/hr)
6	120	1.5	180
9	100	5.5	550
12	90	12.9	1,160
14	85	20.8	1,770
16	80	31.2	2,500
18	75	45.0	3,380
20	70	62.5	4,370
24	65	109.0	7,100

[1]Based on 30 percent trough loading.

The horsepower equation (equation 6.6) includes factors that are needed to overcome feeding surges and that compensate for the extra horsepower required to start the conveyor when it is loaded with material. There are several other factors that can influence power requirements under some circumstances. The reader should refer to the manufacturer's literature for a complete discussion of these factors and for additional information needed in special situations.

Screw elevators are normally used in cotton gins to lift cottonseed from the floor to some elevated component, such as a seed scale or overhead conveyor. A typical elevator consists of a short section of a horizontal screw conveyor feeding a vertical screw conveyor. The vertical section consists of a screw conveyor encased in a cylindrical housing. The handling capacity of a screw elevator is difficult to estimate because of wide variations in important factors, such as screw-housing clearance, fluid characteristics of material, screw length, screw pitch, and lift. When specific operating data are not available from a manufacturer, a rough estimate of the capacity of a screw elevator can be obtained from the formula for theoretical screw capacity. The theoretical capacity is determined as follows:

$$\text{Theoretical capacity} = (D^2 - d^2)PN/36.3, \qquad [6.7]$$

where

D = screw diameter (in inches),
d = shaft diameter (in inches),
P = screw pitch (in inches), and
N = screw speed (in rpm).

The estimated capacity for a screw elevator handling cottonseed will normally be 25–30 percent of the theoretical capacity.

References

Alberson, D.M. 1977. Mechanical conveyors. *In* Cotton Ginners Handbook, pp. 67–69, U.S. Department of Agriculture, Agricultural Handbook 503.

McCaskill, O.L., R.V. Baker, and V.L. Stedronsky. 1977. Fans and piping. *In* Cotton Ginners Handbook, pp. 57–67, U.S. Department of Agriculture, Agricultural Handbook 503.

Screw Conveyor Corporation. 1987. Screw conveyor catalog and engineering manual, No. 787. 64 pp. Screw Conveyor Corporation, Hammond, IN.

Wright, T.E. 1977. Separators and droppers. *In* Cotton Ginners Handbook, pp. 53–56, U.S. Department of Agriculture, Agricultural Handbook 503.

Abatement of Air Pollution and Disposal of Gin Waste

C.B. Parnell, Jr., E.P. Columbus, and William D. Mayfield

Approximately 50–60 percent of the energy consumed by a cotton gin is a consequence of pneumatic conveying. Relatively large volumes of air are needed to move seed cotton, trash, lint, and seed through the ginning process. Typically, 10–20 different fan/motor systems are used to move material from point to point. Each of these systems exhausts its conveying air to the surrounding atmosphere through some type of air pollution abatement system. Usually, centrifugal fan exhausts pass through cyclone collectors, while the axial-flow fan (condenser) exhausts pass through covered condenser drums. It is the gin manager's responsibility to capture and dispose of gin trash and to ensure that the gin's air pollution abatement system functions effectively.

Emphasis on environmental quality is a consequence of the 1970 Federal Clean Air Act and of the subsequent Environmental Protection Agency's (EPA) National Ambient Air Quality Standards (NAAQS) for particulate matter (EPA 1971). Effective July 31, 1987, EPA revised the NAAQS for particulate matter when it announced a new Federal Reference Method (FRM) for measurement of particulate matter having an aerodynamic diameter less than 10 micrometers (PM10) (EPA 1987).

This revision reduces the primary Federal air quality standard from 260 $\mu g/m^3$ total suspended particulate to 150 $\mu g/m^3$ PM10 for a 24-hr time-weighted average. No more than one measured exceedance per year of the PM10 standard is allowed for a given area. If the standard is exceeded more than twice in 1 yr in a designated area, a plan must be developed to bring the area back into compliance with the standard. In the future the ginning industry will be faced with even more of a challenge to control particulate emissions.

The engineering associated with the trash/dust collection system of a gin plays a significant role in the total amount of dust emitted by the gin's materials handling system. Even if the gin has a well-engineered system, the total dust emitted varies with time of harvest and harvesting method. Increased dust emissions result from processing late-harvested cotton. Gins processing mechanically stripped cotton emit more dust than those processing mechanically picked cotton.

Cotton Gin Trash

Approximately 26 percent (Glade and Johnson 1983–1985) of the annual U.S. cotton crop is harvested by mechanical strippers; 73 percent is harvested by mechanical pickers; and 1 percent is scrapped cotton. The amount of seed cotton needed to produce one 480-lb bale of lint is about 1,500 lb for picked cotton and 2,260 lb for stripped cotton. The trash and dust in a bale ranges from 75–150 lb for picked cotton and 700–1,000 lb for stripped cotton. In a typical year, cotton gins in the United States processing spindle-picked cotton will handle 500,000–1 million tons of cotton gin trash. Those processing stripped cotton will manage 1 to 1-1/2 million tons of trash.

Common disposal methods for cotton gin trash include the following: (1) composting, (2) using it for cattle feed, and (3) direct application to land using spreader trucks. Caution should be used when feeding gin trash to cattle, since pesticide residues may be present in the trash. Cotton gin trash from a crop treated with arsenic acid should never be fed to cattle. Incineration is not allowed in most States and will likely be even less acceptable in the future. Composting of gin trash offers potential to reduce the negative attributes of "raw" gin trash. If this material is composted properly, there should be minimum live weed seeds and live disease organisms and the trash volume should be reduced 40 percent. The resulting compost is valuable as a soil additive because it contains substantial nutrients.

The most common method of disposing of cotton gin trash is direct application to land using spreader trucks. Each ginner using this technology spends approximately $10/ton of trash disposed. This cost is dependent upon the distance the trucks must travel to get to the disposal site. It is becoming difficult in some areas for ginners to acquire sites for trash disposal. At $10/ton to spread trash on the land, the cotton ginning industry would spend $15–$25 million each year for solid waste disposal. The gin trash, however, does return nutrients to the soil.

Air Pollution

The goal of air pollution control is to minimize deterioration of air resources so that the public can breathe the best quality air possible. Typically, a construction permit must be obtained from the State air pollution control agency prior to initiation of gin construction. In addition an operating permit must be approved by this agency prior to operating, and this permit must be kept current. Construction permits are also needed before modifying existing facilities if the modifications may increase emissions. State air pollution agencies usually have authority to administer penalties and fines to violators. The time required to obtain permits can exceed 90 days in some States. It is important that gin management be aware of and comply with the permitting requirements in their State.

In some States, the EPA standards entitled "Particulate Emission Factors For Cotton Gins With Controls" (1985) are used for permitting gins. Table 6–10 summarizes some of the factor ratings established in that publication. According to EPA emission factors, a gin that has controls and processes 10 bales/hr should emit no more than 22.4 lb/hr of total particulate, with the major emissions being from the unloading fan (3.2 lb/hr) and from the number 1 lint cleaner condenser (8.1 lb/hr). Other information regarding emission factors is available in EPA standards (1975, 1978), Kirk et al. (1979), National Enforcement Investigations Center and EPA Region IX (1978), and Parnell and Baker (1973).

Table 6–10.
Maximum particulate emission factor ratings allowed for cotton gins with controls

Emission source	Maximum emission factor allowed lb/bale[1]	g/kg
Unloading fan	0.32	0.64
No. 1 dryer and cleaner	0.18	0.36
No. 2 dryer and cleaner	0.10	0.20
Trash fan	0.04	0.08
Overflow fan	0.08	0.16
No. 1 lint cleaner condenser	0.81	1.62
No. 2 lint cleaner condenser	0.15	0.30
Mote fan	0.20	0.40
Battery condenser	0.19	0.38
Master trash fan	0.17	0.34
Total factor allowed	2.24	4.48

[1]For bale of cotton weighing 500 lb (227 kg).

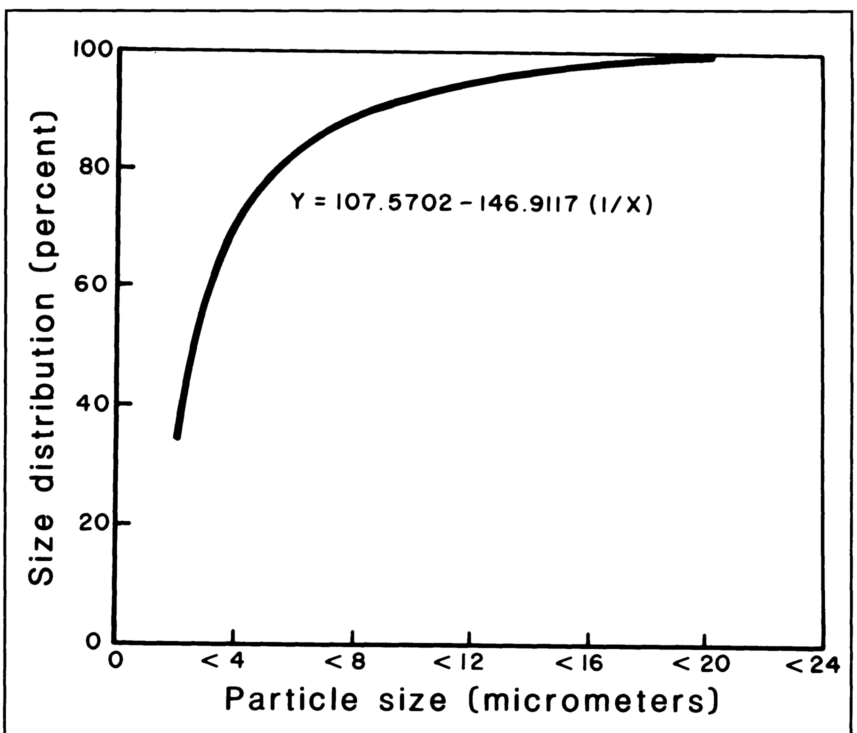


Figure 6–14. Percentage of various sizes of gin trash particles emitted from exhaust of a 2D–2D cyclone

Gins processing picked and stripped cotton use 7,000 and 8,000 ft^3 air/min for each bale per hour of rated capacity, respectively. For example, a gin rated at 10 bale/hr of stripped cotton uses approximately 80,000 ft^3/min. Approximately 40 percent of this total (32,000 ft^3/min) is associated with axial-flow fan (condenser) exhausts, which require a relatively large rate of flow to obtain uniform batts of lint for lint cleaners and for the battery condenser at the lint slide above the press. The remaining 60 percent of the air used for pneumatic conveying in a gin is attributed to centrifugal or high-pressure fan exhausts.

High-Efficiency Cyclones

Cyclones are the most widely used air pollution abatement equipment for cotton gins (McCaskill and Wesley 1974). Typically, they are used on high-pressure (centrifugal fan) discharges, where they collect the bulk of the waste being discharged. Cyclones are used extensively because they are effective and inexpensive and require low maintenance. A cyclone consists of a cylindrical upper body, a conical lower section, and a smaller center cylinder that extends from the top to just below the opening where the relatively clean air is discharged. The trash-laden air enters tangentially near the top. Centrifugal force caused by the whirling action of the trash and air pushes the trash outward and down through the conical section to a collection point below the cyclone. The air moves up through a center vortex and out through the center cylinder.

A properly sized high-efficiency cyclone collects 99.9 percent of the total trash introduced (Baker and Stedronsky 1967) and virtually 100 percent of the trash larger than 30 micrometers in diameter (fig. 6–14) (Wesley et al. 1972). The two most-often-used cyclone designs for trash/dust collection by agricultural processing facilities are commonly referred to as the 2D–2D and 1D–3D (figs. 6–15 and 6–16). These designations refer to the ratio of cylinder length to cone length. The "D" is the characteristic dimension of the cyclone (Dc), i.e., the diameter of the cylinder. The 2D–2D cyclone has a cylinder length and cone length equal to twice the length of the cylinder diameter. The 1D–3D cyclone has a cylinder length equal to the length of the cylinder diameter and has a cone that is three times the length of the cylinder diameter. Entrance dimensions are another significant design difference. The 1D–3D cyclone entrance is long and narrow compared to the rectangular entrance of the 2D–2D.

Sizing Cyclones

Typically, cyclones are designed for each centrifugal fan discharge of a gin. The cyclone size and arrangement depends on several variables. An important factor is the volume of air to be handled. It is extremely important to size cyclones to the flow rate to be handled by the cyclone. Oversized cyclones will result in reduced collection efficiency. Undersized cyclones may wear out sooner than normal due to abrasion and may cause back pressure and/or chokages. The cylinder diameter (Dc) is determined by the volume of air passing through the cyclone. If a gin discharge of 10,000 ft^3/min is passed through 2, 3, or 4 cyclones, the volume of air passing through the individual cyclones is 5,000, 3,333, or 2,500 ft^3/min, respectively. When 2, 3, or 4

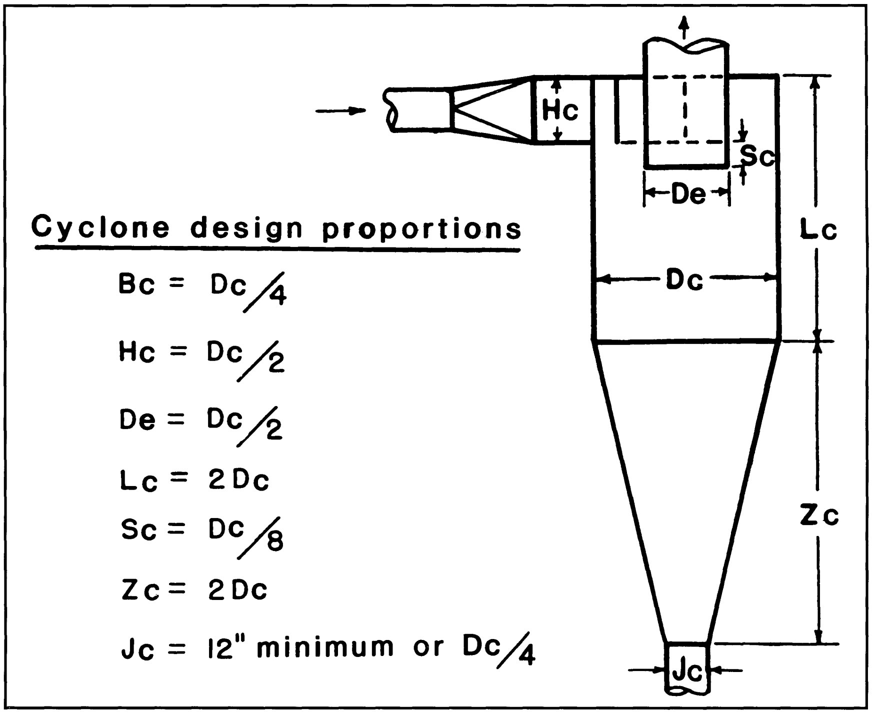


Figure 6–15. Relative dimensions for the 2D–2D cyclone

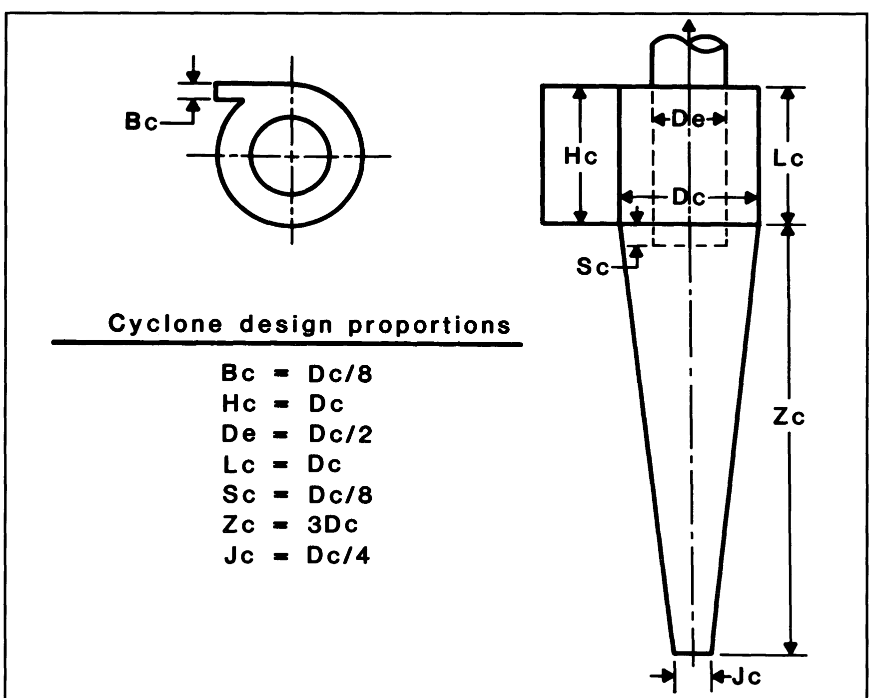


Figure 6–16. Relative dimensions for the 1D–3D cyclone

cyclones are used to handle a 10,000 ft^3/min discharge, the size (Dc) of the cyclones should be 44, 36, or 30 inches, respectively, for 2D–2D cyclones (table 6–11) and 42, 34, or 30 inches, respectively, for 1D–3D cyclones (table 6–12). Figures 6–17, 6–18, and 6–19 illustrate typical cyclone arrangements.

Engineering Parameters for Cyclones

The pressure drop or loss associated with the operation of cyclones is another important factor to consider in the design of a trash/dust collection system. From Jorgenson (1970) three equations are quite useful in cyclone design. The following equations can be used to calculate the pressure drops associated with standard 2D–2D and 1D–3D designs:

2D–2D design:

$$\Delta P = 4.7\ (Pvi + Pvo) \qquad [6.8]$$

1D–3D design:

$$\Delta P = 4.9\ (Pvi + Pvo), \qquad [6.9]$$

where

Pvi = velocity pressure (in inches of water) associated with air entering the cyclone,
Pvo = velocity pressure (in inches of water) associated with air leaving the cyclone, and
ΔP = pressure drop (in inches of water) within the cyclone.

The ideal air velocities for 2D–2D and 1D–3D cyclones are 3,000 and 3,200 ft/min, respectively. The standard 2D–2D and 1D–3D cyclones have exit pipe diameters equal to one-half of Dc. Hence, exit air velocities are equal to the entrance velocity divided by $\pi/2$, or 1,910 and 2,037 ft/min, respectively, for the 2D–2D and 1D–3D cyclones operating at their respective design velocities. Velocity pressures vary with air density. Assuming standard air, velocity pressure can be calculated as follows:

$$Pv = (V/4{,}005)^2, \qquad [6.10]$$

where

V = air velocity (in ft/min) and
Pv = velocity pressure (in inches of water).

As determined by using equations 6.8, 6.9, and 6.10, the corresponding pressure drops for the 2D–2D and 1D–3D cyclones operating at design velocities are 3.7 and 4.6 inches of water, respectively. However, cyclones seldom operate at exactly the design velocity. Usually, engineers design cyclones to operate as near the optimum design velocity as possible while limiting cyclone sizes (Dc) to even numbers, that is, 28, 30, 32, etc. The even-increment cyclones can be sketched and built at local sheet metal shops without too much difficulty. Pressure drop calculations should be

Table 6–11.
Recommended sizes for the 2D–2D cyclone

Air volume (ft^3/min)	Using 1 cyclone		Using 2 cyclones		Using 3 cyclones		Using 4 cyclones	
	Diameter, Dc (inches)	Approximate height (ft)	Diameter, Dc (inches)	Approximate height (ft)	Diameter, Dc (inches)	Approximate height (ft)	Diameter, Dc (inches)	Approximate height (ft)
1,500	24	8	-	-	-	-	-	-
2,000	28	10	20	7	-	-	-	-
2,500	30	10	22	8	-	-	-	-
3,000	34	12	24	8	20	7	-	-
4,000	40	14	28	10	22	8	20	7
5,000	44	15	30	10	26	9	22	8
6,000	48	16	34	12	28	10	24	8
7,000	-	-	36	12	30	10	26	9
8,000	-	-	40	14	32	11	28	10
9,000	-	-	42	14	34	12	30	10
10,000	-	-	44	15	36	12	30	10
11,000	-	-	46	16	38	13	32	11
12,000	-	-	48	16	40	14	34	12
14,000	-	-	-	-	42	14	36	12
16,000	-	-	-	-	46	16	40	14
18,000	-	-	-	-	48	16	42	14
20,000	-	-	-	-	-	-	44	15
22,000	-	-	-	-	-	-	46	16
24,000	-	-	-	-	-	-	48	16

Table 6–12.
Recommended sizes for the 1D–3D cyclone

Air volume (ft^3/min)	Using 1 cyclone: Diameter, Dc (inches)	Using 1 cyclone: Approximate height (ft)	Using 2 cyclones: Diameter, Dc (inches)	Using 2 cyclones: Approximate height (ft)	Using 3 cyclones: Diameter, Dc (inches)	Using 3 cyclones: Approximate height (ft)	Using 4 cyclones: Diameter, Dc (inches)	Using 4 cyclones: Approximate height (ft)
1,500	24	8	-	-	-	-	-	-
2,000	28	9	20	7	-	-	-	-
2,500	30	10	22	8	-	-	-	-
3,000	32	11	24	8	20	7	-	-
4,000	38	13	26	9	22	8	20	7
5,000	42	14	30	10	24	8	22	8
6,000	46	16	32	11	28	10	24	8
7,000	-	-	36	12	30	10	26	9
8,000	-	-	38	13	32	11	28	10
9,000	-	-	40	14	32	11	28	10
10,000	-	-	42	14	34	12	30	10
11,000	-	-	44	15	36	12	32	11
12,000	-	-	46	16	38	13	32	11
14,000	-	-	-	-	42	14	36	12
16,000	-	-	-	-	44	15	38	13
18,000	-	-	-	-	46	16	40	14
20,000	-	-	-	-	-	-	42	14
22,000	-	-	-	-	-	-	44	15
24,000	-	-	-	-	-	-	46	16

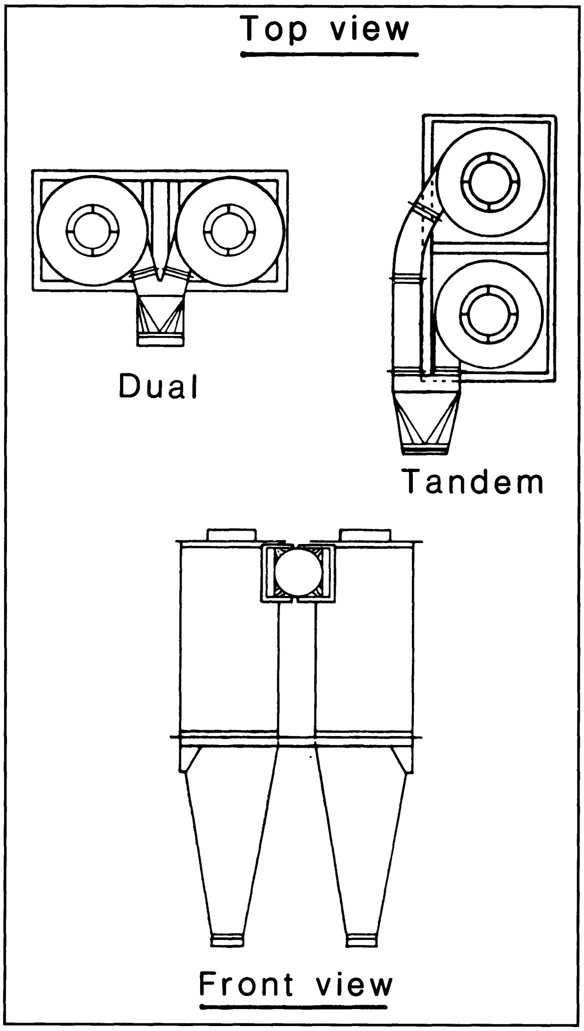


Figure 6–17. Typical arrangement when two cyclones are used

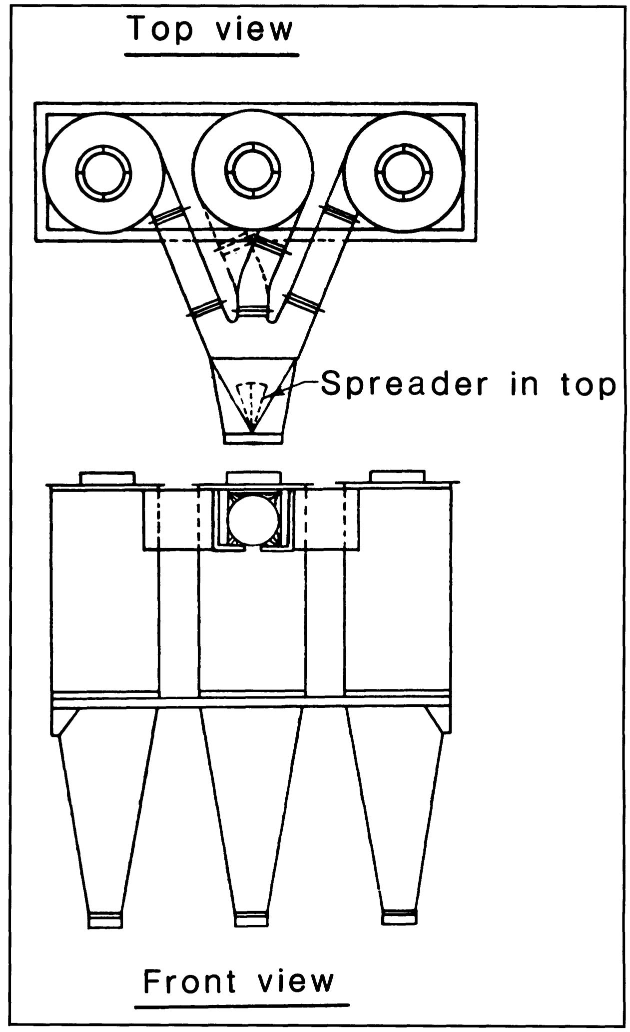
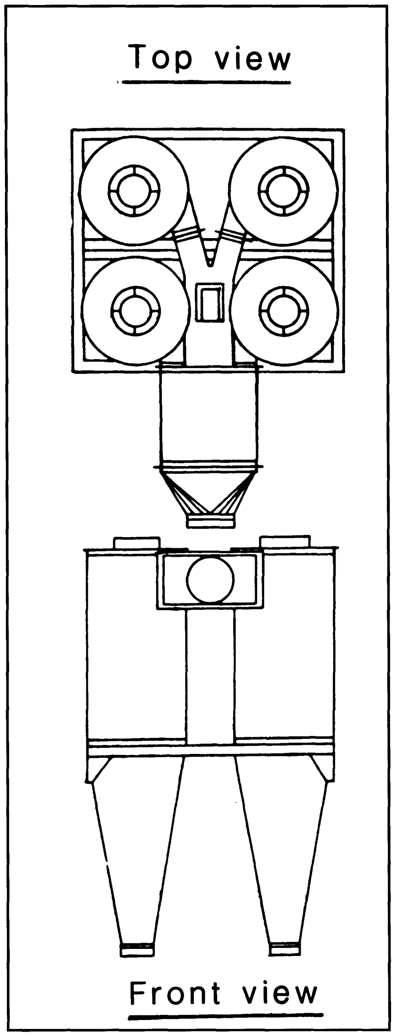


Figure 6–18. Typical arrangement when three cyclones are used

Figure 6–19. Typical arrangement when four cyclones are used



made for each cyclone designed. For example, if three 36-inch-diameter 2D–2D cyclones are used to handle a discharge of 10,000 ft^3/min, the cyclones would have an entrance velocity of 2,963 ft/min and a corresponding pressure drop of 3.62 inches of water. Three 1D–3D, 34-inch-diameter cyclones have an entrance velocity of 3,322 ft/min and a corresponding pressure drop of 4.94 inches of water. Care should be taken to ensure that each cyclone is specifically designed for the discharge it must handle. Generally, a constant cyclone diameter for all cyclones associated with the 10 to 20 emission points of a gin will not be the most efficient design.

Figures 6–20 and 6–21 show the optimum velocity ranges for operating 2D–2D and 1D–3D cyclone collectors, respectively. Also shown are the approximate sizes required for various applications. From these graphs selection should be made between the dashed lines to provide a good compromise of collection efficiency to horsepower load or pressure drop. The dashed lines represent limits of 3.0 to 5.5 inches of water pressure drop (corresponding to inlet velocities of 2,700 to 3,600 ft/min) for the 2D–2D cyclones and 3.5 to 6.0 inches of water pressure drop (corresponding to 2,800 to 3,650 ft/min) for the 1D–3D cyclones.

Space and height limitations are important factors in choosing the number of cyclones to use for each discharge (see tables 6–11 and 6–12). A 48-inch-diameter 1D–3D cyclone will be a minimum of 16 ft high (4-ft body, 12-ft cone). In addition the exit pipe will likely extend at least 1 ft above the top, and usually a bank of cyclones will discharge into an auger conveyor 1–2 ft aboveground. The exit point of this cyclone will likely be 19–20 ft aboveground. A 24-inch-diameter cyclone will only be 11–12 ft high.

For cyclones discharging into screw conveyors, care should be taken to provide sufficient conveyor capacity to prevent stoppages. Conveyors mounted beneath trash-collecting cyclones should be equipped with hoppers to accommodate temporary overloads.

Since the splitter inlet transition on multiple-cyclone arrangements is a potential source of trouble, a single cyclone should be used on each lint cleaner waste fan whenever possible. If the cyclones discharge into a screw

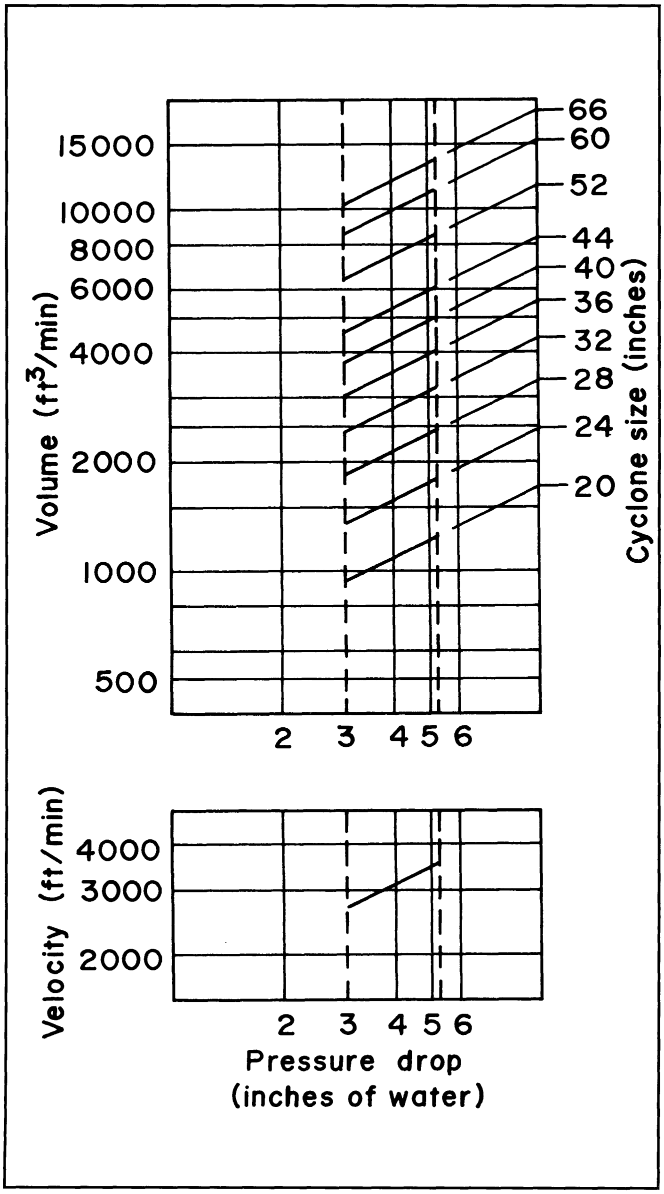


Figure 6–20. Selection chart for 2D–2D cyclones

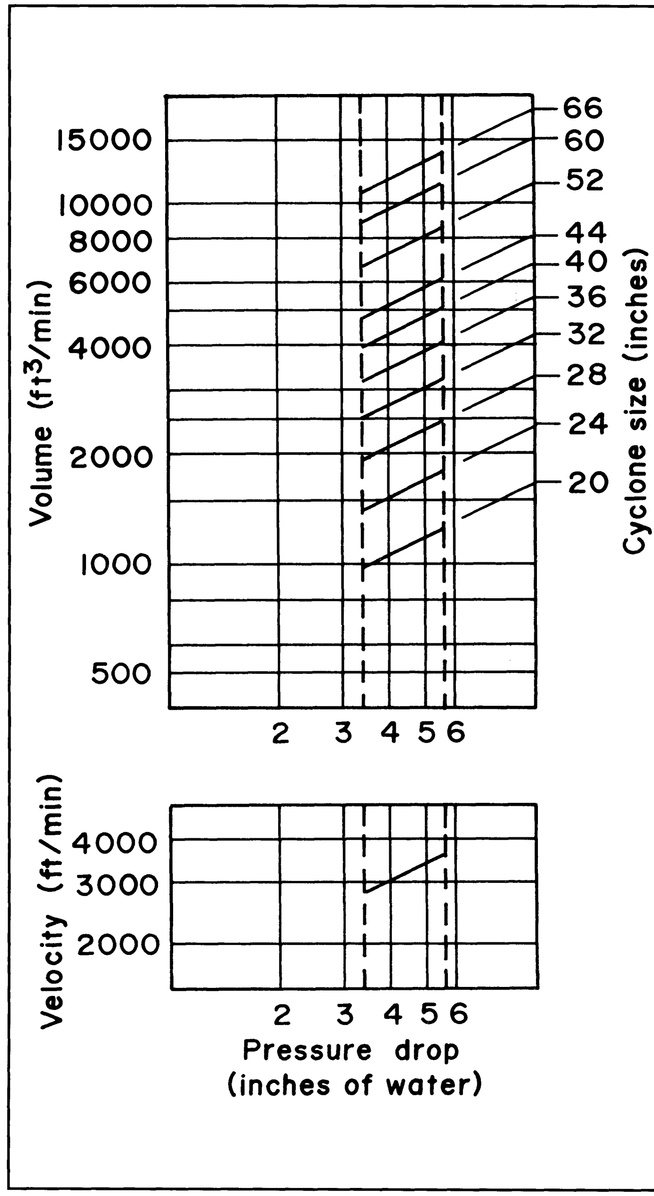


Figure 6–21. Selection chart for 1D–3D cyclones

conveyor, the lint cleaner waste cyclone should be located near the outlet end of the conveyor to minimize conveyor chokage.

In-line Filters

In-line filters were developed specifically for controlling the fly lint and dust emissions from condenser exhausts. Three designs of in-line filters are available (fig. 6–22). Fly lint and small-leaf trash are separated from the exhaust air by a fine-mesh filtering screen. In-line filters are most efficient when operated on a collecting-cleaning cycle controlled by a pressure-differential switch. The switch automatically starts the screen-cleaning action when the pressure reaches a predetermined level; the switch stops the cleaning action when the pressure is relieved. Switches should be adjusted to start the cleaning action before the pressure reaches a level that would critically affect exhaust fan performance.

Tests using machine-picked cotton showed an overall collection efficiency of 87 percent for a stationary-screen in-line filter on the exhaust of a first-stage lint cleaner (Alberson and Baker 1964). Efficiencies of approximately 81 percent were obtained when ginning machine-stripped cotton (Baker and Parnell 1971). Generally, an in-line filter can be expected to collect all of the

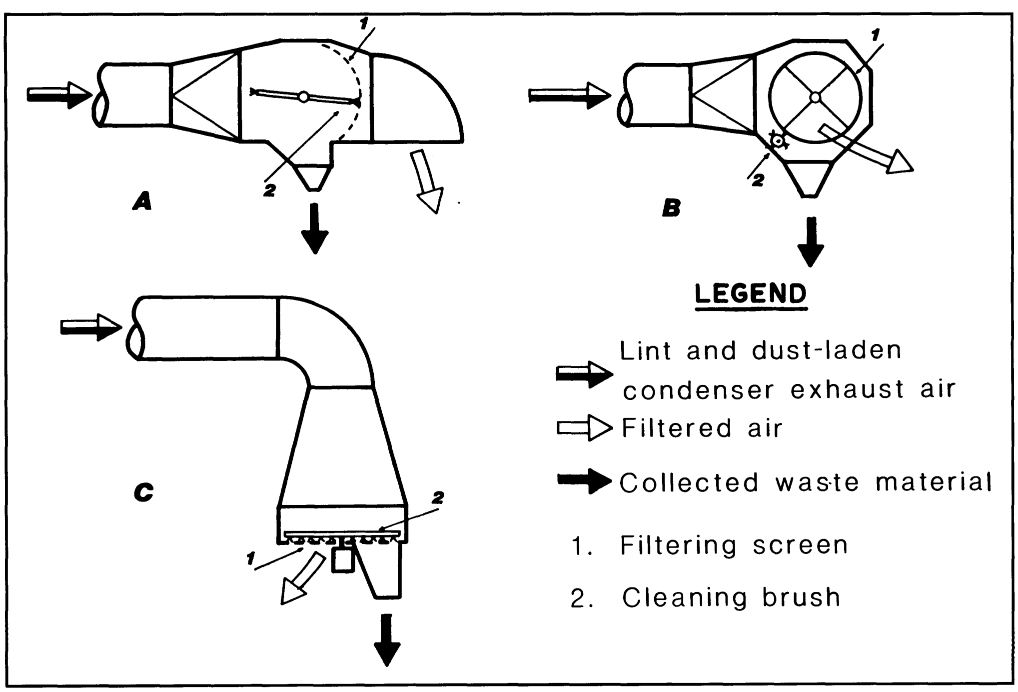


Figure 6–22. Schematic diagrams of three designs of in-line air filters. *A*, Stationary screen type; *B*, Revolving drum type; *C*, Round.

fly lint and up to about 70 percent of the fine dust (Alberson and Baker 1964).

The recommended dimensions of wire cloth in in-line filters are given in table 6–13. The in-line filter screen face velocity should be approximately 750 ft/min. Recommended screen sizes for in-line filters are given in table 6–14.

In-line filters should be inspected daily throughout the active ginning season. Accumulations of lint on the brushes should be removed, and the waste exit should be unobstructed. Any clogs in the filtering screen should be removed with an air hose. Each year in-line filters should be cleaned and inspected. Inspections should include observations of brush contact, screen condition, clearance through waste exit and mote lines, tension and alignment of chain drives, and accumulations of lint material in the electric motors.

Condenser Drum Covering

Short fibers and dust exhausted from condenser fans are probably the most objectionable emissions to gin employees and residents of the immediate area. This lint fly settles on electric lines, the gin yard, rooftops, and surroundings, causing not only a housekeeping problem but a serious fire hazard.

Tests have shown that the lint fly problems can almost be eliminated by covering condenser drums with a fine-mesh stainless steel screen wire or with fine perforated metal (McCaskill and Moore 1966, Columbus and Anthony 1991). If covers are used, only the very fine dust is discharged with the exhaust air. The screen wire can be either 100 by 100 mesh, 80 by 80 mesh, or 70 by 70 mesh. The fine perforated metal should have holes of 0.045-inch diameter; however, perforated metal with holes of 0.033-inch diameter has been used in the past. Table 6–15 shows the size and open area of the different coverings and shows the dust concentration emitted through each covering. Table 6–16 shows similar data for emissions from coverings placed on a battery condenser. Pressure drops across these coverings range from 1/2 to 1 inch of water. The slight increase in air resistance is not a problem where exhaust fans are used; however, the additional resistance may require adjustments to the condenser air system to ensure proper batting and doffing.

Figure 6–23 shows how a screen is applied to a standard condenser. The screen is stretched smoothly over the condenser drum and soldered around each end. The screen is also soldered longitudinally across the drum where seams are necessary. After the screen is applied, it is necessary to adjust the doffing rollers to ensure clearance for the drum.

CAUTION: Condenser drums that have been blanked off so that no more than one-fourth of the drum area is exposed to the inlet air should not be covered with screen. Ample exposed drum area is necessary to compensate for the reduction in open area when fine screen is applied.

Table 6–13.
Specifications for bolting-grade wire cloth used in in-line filters

Mesh of screen (wires/inch)	Wire diameter (inches)	Size of opening (inches)	Open area (percent)	Pressure drop at 750 ft/min face velocity (inches H_2O)
40 by 40	0.0065	0.0185	54.8	0.04
70 by 70	0.0037	0.0106	54.9	0.05
105 by 105	0.0030	0.0065	46.9	0.10

Table 6–14.
Recommended screen sizes for in-line filters

Condenser capacity (bales/hr)	Exhaust volume[1] (ft^3/min)	Exhaust fan diameter and type[2] (inches)	Gross screen area required[3] (ft^2)	Stationary screen[4] Radius (inches)	Stationary screen[4] Width (inches)	Revolving drum diameter[5] (inches)	Round filter diameter (inches)
Up to 2	Up to 3,000	V18	5.3	15	30	20	31
2 to 4	3,000 to 6,000	V18 to V21	10.6	21	42	30	44
4 to 6	6,000 to 9,000	V21 to T36	15.9	25	50	35	54
6 to 8	9,000 to 12,000	V24 to T42	21.2	29	58	41	62
8 to 10	12,000 to 15,000	V26 to T42	26.5	32	64	46	70
[6]10 to 15	15,000 to 20,000	T42	35.6	38	76	53	81
[6]15 to 20	20,000 to 25,000	T42	44.4	42	84	59	90

[1]Measured without lint in the system.
[2]Vaneaxial or tubeaxial types indicated by letters V or T, respectively.
[3]Based on 750 ft/min face velocity and a 25-percent loss in area for screen supports.
[4]Based on a 120° screen arc.
[5]Assumed to be equal to the length of the revolving drum.
[6]Press condensers only.

Table 6–15.
Dust and lint fly emitted from a unit lint cleaner condenser with various types of coverings

Type of drum covering and hole diameter	Holes per in^2	Open area (percent)	Lint fly and dust concentration (g/1,000 ft^3)	Static pressure loss (inches H_2O)
Perforated metal, 0.109-inch diameter (standard)	47	45	50.8	0.52
Perforated metal, 0.033-inch diameter	234	20	32.0	0.70
100-mesh screen (31.4 percent open area) over standard drum (45 percent open area)	(1)	14	21.6	0.75
70-mesh screen (54.9 percent open area) over standard drum (45 percent open area)	(2)	25	(3)	(3)

[1]0.0056 inch between mesh.
[2]0.0106 inch between mesh.
[3]No data available.

Table 6–16.
Dust and lint fly emitted from a battery condenser with various types of coverings

Type of drum covering and hole diameter	Holes per in^2 or hole size	Open area (percent)	Total emission concentration ($g/1000\ ft^3$) after: 0 lint cleaners	2 lint cleaners
Perforated metal, 0.118-inch diameter (reference)	34 holes	37.2	5.03	1.80
Perforated metal, 0.045-inch diameter	172 holes	27.5	3.94	1.57
100-mesh screen (36.0 percent open area) over reference covering[1]	.0060 inches	13.4	3.23	1.39
80-mesh screen (31.4 percent open area) over reference covering[1]	.0070 inches	11.7	3.22	1.43
70-mesh screen (29.8 percent open area) over reference covering[1]	.0073 inches	11.1	3.30	1.20

[1]When the 100-mesh, 80-mesh, or 70-mesh wire is placed over 10 by 10 or 8 by 8 mesh wire, the open area is essentially that of the fine wire mesh only. Emissions should be similar to that for the fine mesh over the 0.118-inch perforated metal.

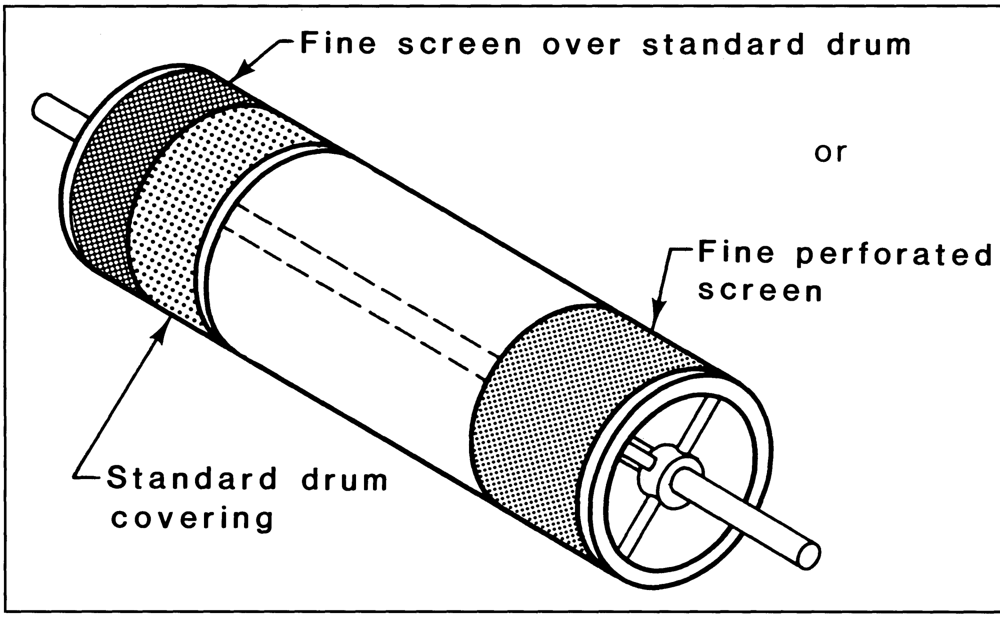


Figure 6–23. Condenser drum covering

Rotary Drum Collection System

Figure 6–24 shows an enclosed rotary drum trash-collection system composed of a settling chamber equipped with an impinging baffle and a revolving drum; the drum is covered with a filter medium. Cleaned air is discharged from both ends of the filter drum. Original tests showed a high collection efficiency (table 6–17) and low pressure drops (McCaskill and Wesley 1976). Table 6–18 contains specifications and capacities for several face velocities and drum sizes of rotary drum collection systems. Field experience indicates that the machines have frequent chokages and operational failures causing gin downtime and the need for close attention during operation. Most of these units have been operated as secondary collectors after cyclones; however, this use greatly increases the operational costs of these devices. Economic data indicate that the rotary drum filters cost about 2–4 times as much as a cyclone system.

Trash Houses/Bur Hoppers

Prior to final disposal, it is usually necessary for cotton gins to store gin trash temporarily. Elevated trash houses provide a convenient means of accumulating truckloads of gin trash and also expedite the loading of the trash onto trucks (fig. 6–25). Loading is accomplished by simply opening the bottom of the trash house to allow the accumulated trash to fall into the truck.

Trash houses are available in lengths of 20, 30, and 40 ft. A gin processing 20 bales/hr of spindle-harvested cotton would need about 200–440 ft^3 of temporary storage whereas a gin processing stripper-harvested cotton at the same rate would require about 2,000–2,900 ft^3 of storage. The house size

Figure 6–24. Schematic of a unifilter (rotary drum) trash-collection system

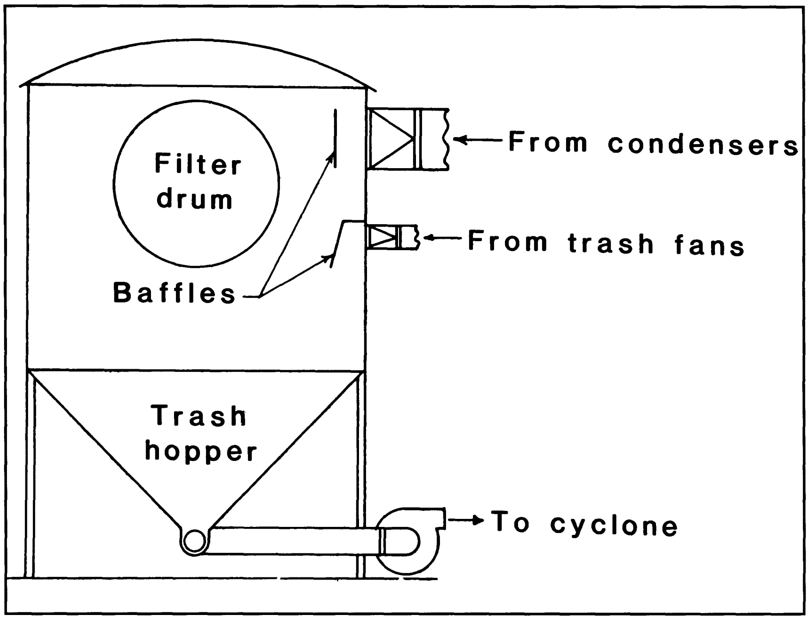


Table 6–17.
Overall filter efficiency of a rotary drum collection system at three ginning rates

Ginning rate (bales/hr)	Trash input (lb/hr)	Overall efficiency (percent)
4	571	99.23
6	851	99.36
8	1,097	99.55

Table 6–18.
Specifications and capacities (air volume) of rotary drum collection systems operating at various face velocities

Drum diameter (ft)	Filter area (ft^2)	Number of nozzles	Air volume (ft^3/min) at face velocity of: 100 ft/min	150 ft/min	200 ft/min	250 ft/min
4	50.4	2	5,040	7,560	10,080	12,600
4	75.6	3	7,560	11,340	15,120	18,900
5	62.8	2	6,280	9,420	12,560	15,700
5	94.2	3	9,420	14,130	18,840	23,550
5	125.6	4	12,560	18,840	25,120	31,400
6	75.2	2	7,520	11,280	15,040	18,800
6	112.8	3	11,280	16,920	22,560	28,200
6	150.4	4	15,040	22,560	30,080	37,600
7	88.0	2	8,800	13,200	17,600	22,000
7	132.0	3	13,200	19,800	26,400	33,000
7	176.0	4	17,600	26,400	35,200	44,000
7	220.0	5	22,000	33,000	44,000	55,000
8	150.0	3	15,000	22,500	30,000	37,500
8	200.0	4	20,000	30,000	40,000	50,000
8	250.0	5	25,000	37,500	50,000	62,500
8	300.0	6	30,000	45,000	60,000	75,000
9	169.8	3	16,980	25,470	33,960	42,450
9	226.4	4	22,640	33,960	45,280	56,600
9	283.0	5	28,300	42,450	56,600	70,750
9	339.6	6	33,960	50,940	67,920	84,900
10	188.4	3	18,840	28,260	37,680	47,100
10	251.2	4	25,120	37,680	50,240	62,800
10	314.0	5	31,400	47,100	62,800	78,500
10	376.8	6	37,680	56,520	75,360	94,200

Figure 6–25. Typical trash house and spreader truck used in gins handling spindle- and stripper-harvested cotton (PN-5245)

required depends upon the type of cotton being ginned, the ginning rate, and the number of trucks being used to haul trash. Low-capacity gins processing less than eight bales of stripped cotton per hour or gins processing spindle-harvested cotton usually require a 20-ft house. Higher capacity gins processing spindle-harvested cotton and especially those processing stripped cotton require the 30- or 40-ft house.

Trash should be dropped into the house by cyclone collectors. All of a gin's cyclone collectors may be mounted on top of the hopper. However, this location has disadvantages—the collectors are inaccessible and are at high risk for wind damage. In recent years, it has become common for gins to group most of their cyclones into a bank located close to the ground and to concentrate the separations from each collector into a single air line discharging into a single set of collectors on top of the house (fig. 6–26).

Fugitive-Dust Control

Many States have enacted air pollution regulations relative to fugitive-dust control. Fugitive dust is defined as visible emissions released from sources other than stacks, that is, cyclones or vents. Examples of fugitive dust include dust blowing from storage piles, road dust, and emissions leaking from sides of buildings or open areas in buildings. Cotton gins may release

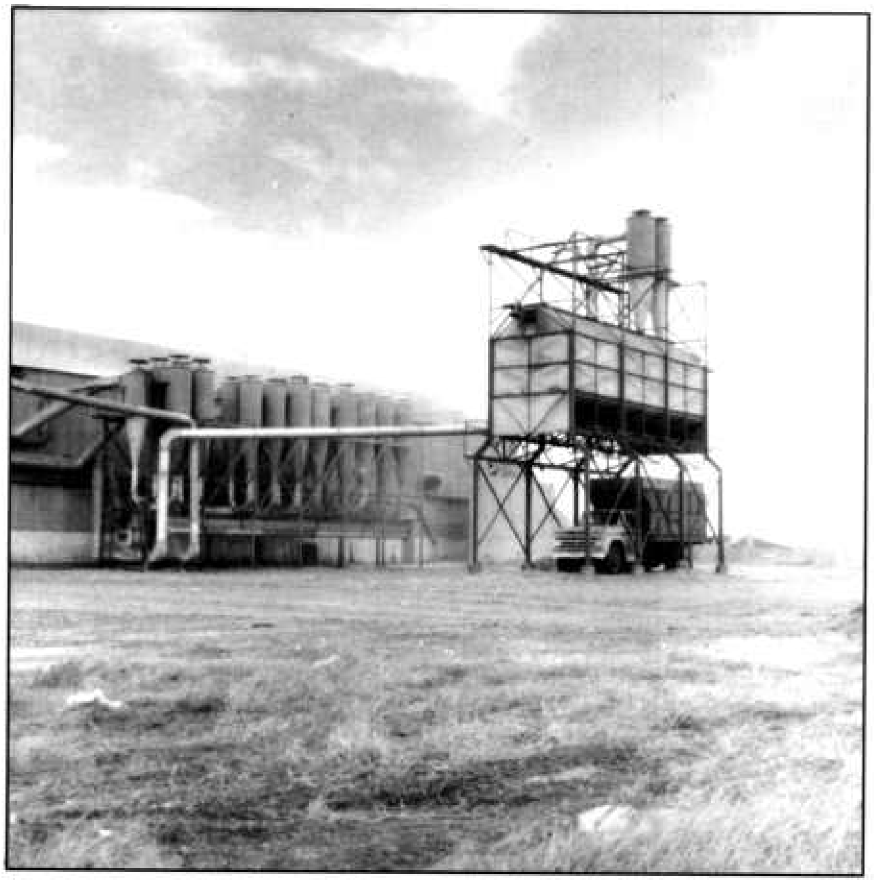


Figure 6–26. A well-designed trash collection system with the main cyclone bank located near the ground and one pair of cyclones loading the trash house (PN–5247)

fugitive dust when waste is dumped from waste piles, trash houses, or cyclones into trucks or trailers. Dust can also become airborne from traffic on the gin grounds. The following control measures may be considered if fugitive dust is a problem:

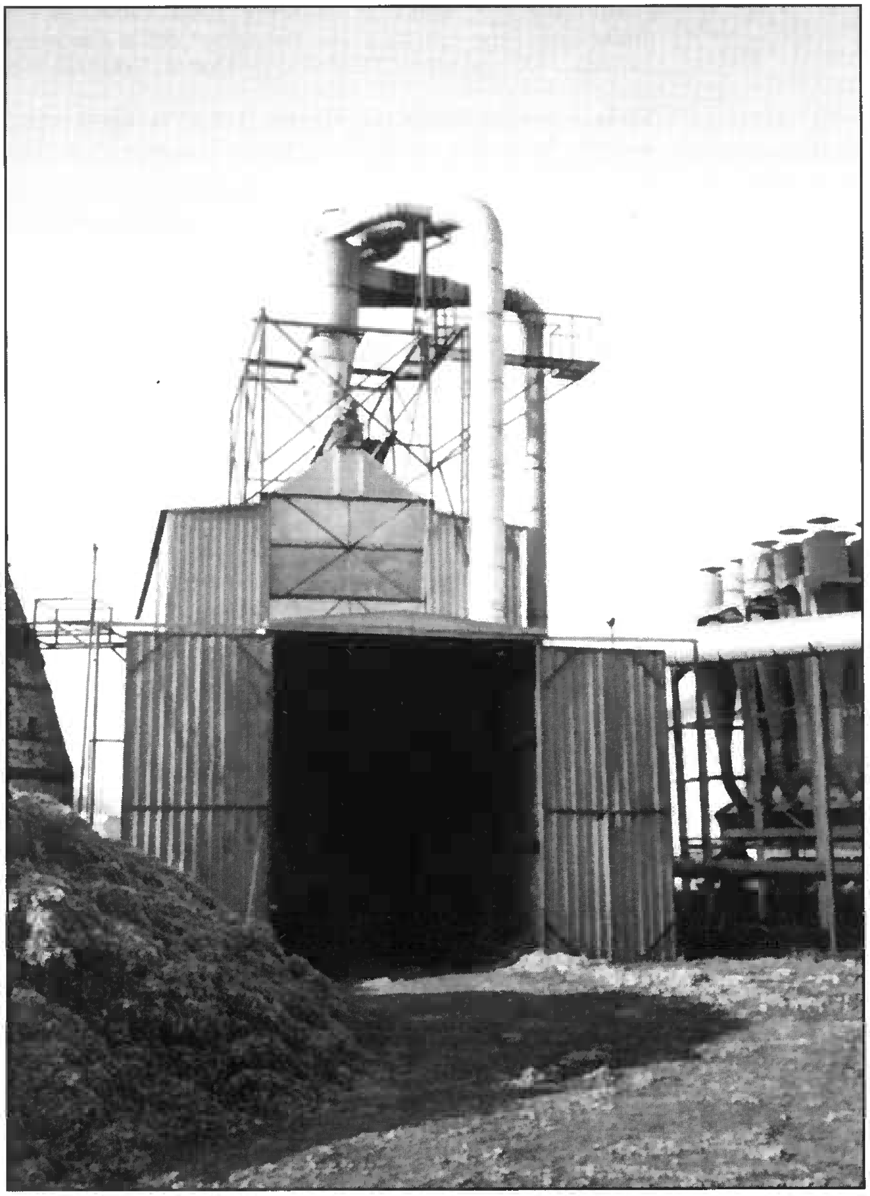
1. For gins using one or more cyclones to drop trash into a pile, attach a nozzle spray system to the cyclones and add water to them to suppress or eliminate fugitive dust. The water added will also promote composting of the waste. Some States require this method of control.

2. Plant pine trees or other tall, fast-growing trees near waste piles to serve as a windbreak. Other windbreaks such as large, shielded enclosures or commercial windshields may be used.

3. Where needed, use side enclosures of sheet metal or tarpaulin to prevent wind from blowing emissions during unloading operations (fig. 6–27). Some State regulatory agencies require total enclosure of the trash houses, depending upon the location of the gin.

4. Construct a side enclosure or trash house in gins in which trash is loaded directly from cyclones into a trailer.

Figure 6–27. Completely enclosed trash house with doors open and a pair of cyclone collectors mounted on top



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Cottonseed Handling and Storage

M. Herbert Willcutt and William D. Mayfield

For every bale of cotton ginned, about 800 lb of seed must be handled and placed either in a temporary or long-term storage facility. Traditionally, gins were only equipped with overhead-type storage houses used to temporarily hold accumulated seed until it could be taken to a cottonseed oil mill for long-term storage. Recently, many gins have built on-site long-term storage facilities that can be filled directly from the gin.

Normally 5–7 million tons of cottonseed are produced annually in the United States. About 60 percent is processed into oil, meal, and hulls; 38 percent is fed to livestock and the remaining 2 percent used for planting. Typical product yield from an oil mill is shown in table 6–19.

Seed Quality

Cottonseed quality is determined by the degree of weathering that the seed cotton received in the field, conditions of seed cotton storage, mechanical damage during harvesting and ginning, conditions during storage after ginning, and contamination. Cottonseed stored at excessive moisture will likely develop a rancid flavor and contain an elevated level of free fatty acid.

Seed quality tests that determine the value and suitability for specific uses are available from public and private labs. Oil-mill grade reports reflect a composite grade computed from the percentage of oil, ammonia, foreign matter, moisture, and free fatty acid. Seed moisture is normally determined

Table 6–19.
Typical product yield from an oil mill

Product	Percent	lb/ton of whole seed
Linters	7	169
First cut	2.5	30–50
Second cut	4.5	100–120
Hulls	25	512
Meal	44	923
Oil	16	318
Waste and moisture	8	78
Total	100	2,000

by weighing seed before and after drying (which is performed at 215–230 °F for a 10-hr period) and expressing the weight lost to drying as a percentage of the wet-seed weight.

Contaminants may either reduce seed value or render the seed completely useless. Good housekeeping practices are necessary to prevent contamination. Contamination may occur during the growing season, the harvesting and handling of seed cotton, the ginning process, or subsequent handling of seed enroute to the final point of use. Contaminants may be excessive residues from pesticides and defoliants applied to the crop or may be bulky items such as plant debris, rocks, scrap metal, hardware, plastic, rubber, or pieces of clothing.

Characteristics of Cottonseed

Whole, fuzzy cottonseed has some unique characteristics that make it impossible to handle with a tube grain auger. Thus, common grain bins and grain-handling facilities are unsatisfactory for cottonseed storage. The basic handling and storage characteristics of whole cottonseed and cottonseed products are shown in table 6–20.

Unlike most grain, cottonseed has a variable angle of repose. The apparent angle of repose when an unrestricted pile of cottonseed is formed is about 45°. However, after the seed has settled and compacted to storage density, it will bridge—an indication that the angle of repose is greater than 90°. Thus,

Table 6–20.
Basic properties of cottonseed and its products

Component	Density (lb/ft^3)	Specific volume (ft^3/ton)	Weight (lb/bu)	Count (No. seed/lb)
Whole seed (gin run)				
Loose on conveyor	20	100	—	1,800–2,400
<24 ft deep	25	80	32–35	—
24–50 ft deep	27	75	—	—
>50 ft deep	30	70	—	—
Machine delinted	35	57	44	2,400–3,200
Acid delinted	34–37	54	42–46	4,800–5,600
Meal (extracted)	38	53	—	—
Hulls	12	167	—	—
Oil	57.45	34.8	—	—

the working angle of repose for filling is about 45° and for emptying is greater than 90°. The effective angles of repose for cottonseed and cottonseed products are shown as follows:

Cottonseed or product	Angle of repose (degrees)
Whole seed during	
Filling	45
Emptying	>90
Acid delinted seed	35
Meal	40–43
Hulls	43

Air-Handling Systems for Cottonseed

The high-pressure, lobed-blower seed-handling systems commonly used in gins handle cottonseed effectively, are economical to operate, and are relatively trouble free. They have adequate capacity for moving seed as fast as the cotton is ginned. They may also be used for carrying seed to and from storage facilities on the gin yard (Smith 1975).

Systems having a pressure of 1–6 psi can convey cottonseed through up to 700 ft of piping. Since no two systems are alike in length and in the number of risers and elbows, the limitations of pressure and volume must be carefully considered in the design of any particular system.

A typical small-pipe system is shown in figure 6–28. A self-cleaning seed belt is used to feed the dropper (vacuum lock) that introduces the seed into the positive-pressure air pipe. A valve enables the seed to be diverted to a truck or a bin or to long-term storage.

Piping

Flanged pipes with rubber gaskets at the joints are normally used to transport cottonseed. Table 6–21 gives the seed-handling capacity of various-sized pipes.

Most pipes are made of aluminum, but 20-gauge galvanized pipe or galvanized tubing may be used in areas exposed to the weather. PVC piping causes static electricity problems and should not be used. On the blower intake and discharge or at points ahead of the seed dropper, standard threaded pipe and fittings can be used for handling the compressed air.

Figure 6–28. Small-pipe system for conveying cottonseed. *A*, 16-mesh air filter, or screen box; *B*, Rotary positive-pressure blower; *C*, Dropper or vacuum-wheel feeder with eight or more shallow pockets; *D*, Gin stand seed belt (diameter of belt wheel may be 4–10 inches); *E*, Long-sweep large-radius elbow; *F*, Valve for diverting seed to bin or storage; *G*, Six-bolt flange and rubber gasket; *H*, Funnel discharge for efficient delivery.

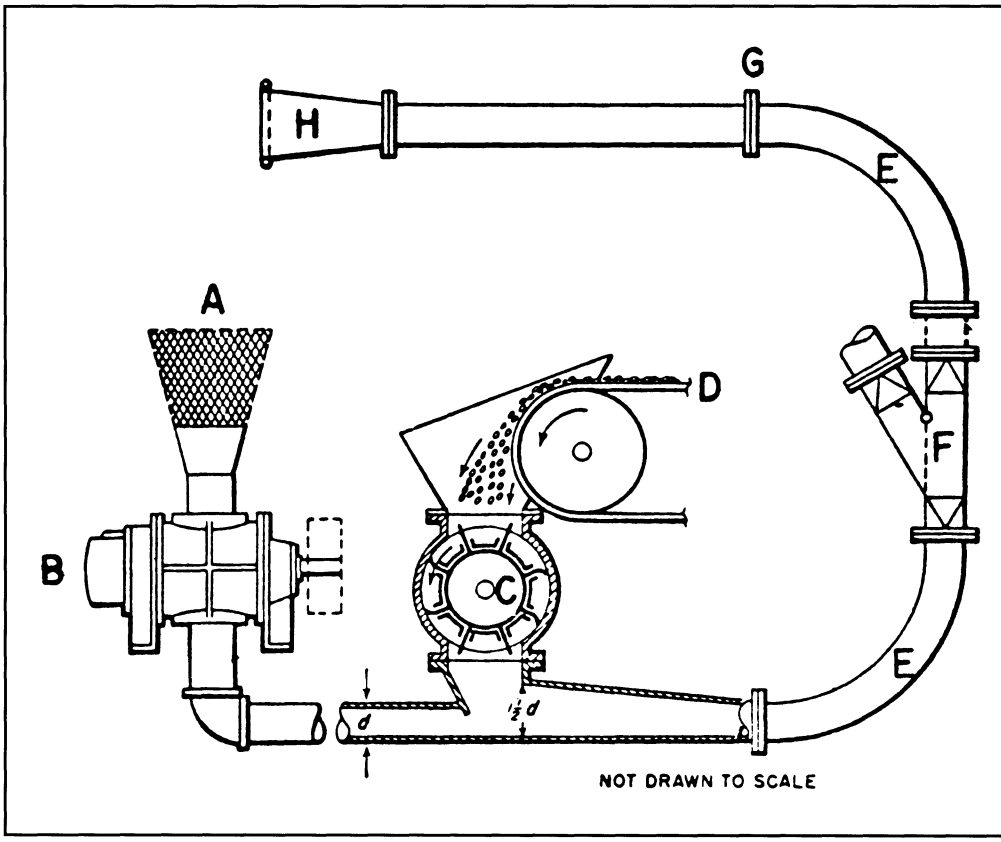


Table 6–21.
Cottonseed handling capacities of pipes

Pipe diameter (inches)	Volume of air[1] (ft^3/min)	Capacity lb/min	Capacity tons/hr	Capacity bales/hr[2]
4	436	128	3.8	10
5	682	200	6.0	16
6	982	288	8.6	22–24
8	1,745	512	15.4	36–42
10	2,727	682	20.4	50

[1]Based on a velocity of 5,000 ft/min.
[2]Based on 800 lb seed/bale.

The total resistance that the pump must overcome can be estimated by allowing 1 psi for each 200 ft of piping (Rayburn et al. 1977). Each short elbow and valve should be considered equivalent to approximately 15 ft of straight pipe. The pressure losses for other elements in the system may be estimated from the following:

Components of pipe conveying systems	Estimated pressure loss (oz/inch^2)
4-inch piping, each 100 ft	6.0
5-inch piping, each 100 ft	5.0
6-inch piping, each 100 ft	3.0
8-inch piping, each 100 ft	2.0
10-inch piping, each 100 ft	1.5
For 4- and 5-inch pipes:	
Elbows	.8
Base and tapered discharges from dropper	2.0
Cyclone collector and sacker at end of pipe	1.0
For 6-, 8-, and 10-inch pipes:	
Elbows	.5
Base and tapered discharges from dropper	2.0
Cyclone collector and sacker at end of pipe	1.0

Air velocities for short seed pipes should be in the 4,200–5,200 ft/min range, with 5,000 ft/min the common target. For pipes that are long and straight (i.e., they have few turns that could cause seed damage), velocities may reach 6,000 ft/min. Volumes of about 3 ft^3 of air/lb of cottonseed are satisfactory in short piping systems having few elbows, but 5 ft^3 of air/lb is desirable in systems exceeding 250 ft. No seed should pass through the blower.

Risers in lines should be inclined, not vertical. The angled pipe will prevent 90° bends, allowing larger angles at elbows and saving piping length. Downward pipe slopes should be avoided because they cause chokages.

Seed-handling elbows should be 18 gauge or heavier and must be the long-sweep type to give satisfactory service without chokage. An 18-inch minimum elbow radius is recommended for pipes 4, 5, and 6 inches in diameter. A 24-inch elbow radius should be used for 8-inch pipes, and a 30-inch elbow radius for 10-inch pipes.

Blowers

The two-lobe rotary air pump known as a positive-pressure blower (fig. 6–29) is commonly used in small-pipe systems operating with an air-pressure range of 1–5 lb/inch^2. These blowers can overcome minor chokages by a temporary increase in air pressure, so relief valves are seldom used; however, blower manufacturers recommend them. Air-pressure requirements, suggested equipment, and operating parameters to convey seed are shown in table 6–22. Performance data for the rotary blowers commonly used at cotton gins and seed-handling facilities are given in table 6–23. A screened intake or air filter is imperative on cottonseed-handling blowers to protect the lobes and casing from excessive wear.

Feeding Seed Into Pressure Pipes

Cottonseed is normally fed into a small-pipe system by a dropper or rotary lock (sometimes called a vacuum wheel) that mechanically drops the seed into the positive-pressure air line on the discharge side of the blower. The rotary lock should operate at 30–60 rpm. Internal seals and pocket divisions are necessary to prevent serious air leakage. More flights on a seed dropper will likely provide a better seal. In some installations, 8-blade droppers without flashing or seed plugs at the end of an auger have been used successfully. Feeder base outlets should be sufficiently tapered to prevent bridging and chokage. Outlets should be set as close to the feeder as possible.

Figure 6–29. Cross section of a typical positive-pressure, two-lobe rotary air pump used for conveying cottonseed. Rotation may be reversed if desired.

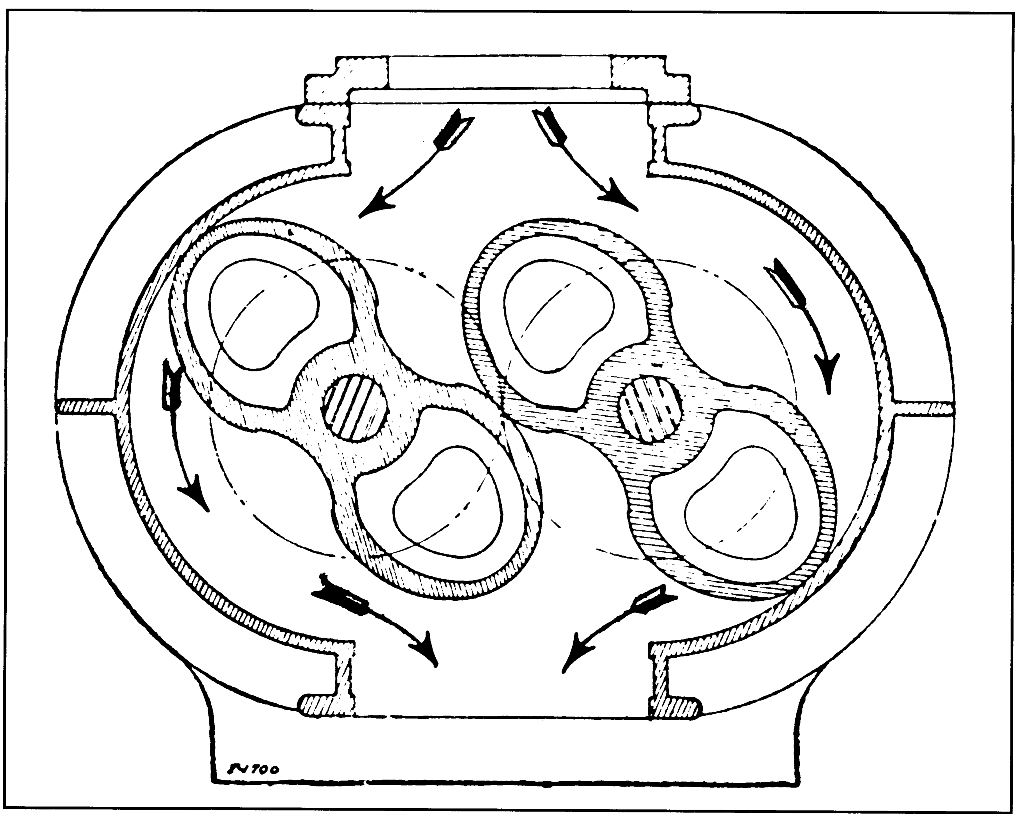


Table 6–22.
Air-pressure requirements, suggested equipment, and operating parameters for seed conveyance at 5 psi

Ginning rate (bale/hr)	Seed rate at 800 lb/bale (lb/min)	Volume requirement at 4 ft^3/min/lb (ft^3/min)	Volume requirement at 5 ft^3/min/lb (ft^3/min)	Blower exhaust diameter (inches)	Recommended blower: Model	Recommended blower: Rpm
10	133	532	665	4	RAI 76	1,935
				5	RAI 68	2,025
				6	RAI 615	1,079
				6	RAI 711	1,042
15	200	800	1,000	6	RAI 615	1,625
				6	RAI 711	1,567
				8	RCS 624J	1,170
				8	RAI 718	946
20	267	1,068	1,333	6	RAI 615	2,164
				6	RAI 711	2,050
				8	RCS 624J	1,475
				8	RAI 718	1,262
25	333	1,332	1,665	[1]6	RAI 615	2,350
				8	RCS 624J	1,740
				8	RAI 718	1,576
				10	RCS 817J	1,350
30	400	1,600	2,000	8	RCS 624J	2,000
				8	RAI 718	1,893
				10	RCS 817J	1,560
35	467	1,868	2,335	8	RCS 624J	2,350
				[1]8	RAI 718	2,050
				10	RCS 817J	1,760
40	533	2,132	2,665	8	RCS 624J	2,650
				[1]8	RAI 718	2,050
				10	RCS 817J	2,000
45	600	2,400	3,000	8	RCS 624J	2,900
				10	RCS 817J	2,220
50	667	2,668	3,335	[1]10	RCS 817J	2,250
				12	RCS 821J	2,100

[1]Diameter limits blower handling capacity to pipe lengths having static pressure below 1 psi.

Table 6–23.
Performance data for rotary positive-pressure blowers

Model No.	Blower exhaust diameter (inches)	Speed (rpm)	Flowrate and horsepower requirements at a static pressure of: 1 psi		2 psi		3 psi		4 psi		5 psi		6 psi		Maximum pressure (inches Hg)	Maximum flowrate (ft^3/min)
			ft^3/min	BHP[1]	ft^3/min	BHP[1]	ft^3/min	BHP[1]	ft^3/min	BHP[1]	ft^3/min	BHP[1]	ft^3/min	BHP[1]		
RAI 76	4	575	195	1.3	179	2.3	168	3.3	158	4.3	150	5.4	142	6.4	12	117
		1,400	526	3.2	511	5.7	500	8.1	490	10.6	481	13.0	473	15.5	16	413
		2,050	788	4.7	772	8.3	761	11.9	751	15.5	742	19.1	734	22.7	15	674
RAI 68	5	700	224	1.5	203	2.7	187	3.9	172	5.1	160	6.3	149	7.5	10	135
		1,760	643	3.8	621	6.8	605	9.8	591	12.9	579	15.9	567	18.9	15	495
		2,350	876	5.0	855	9.1	838	13.1	824	17.2	812	21.2	801	25.3	16	715
RAI 615	6	700	420	2.6	380	4.8	351	7.1	323	9.3	301	11.6	279	13.8	8	292
		1,760	1,205	6.4	1,164	12.1	1,133	17.8	1,107	23.5	1,084	29.1	1,063	34.8	12	997
		2,350	1,641	8.6	1,601	16.1	1,570	23.7	1,544	31.3	1,521			46.5	12	1,433
RAI 711	6	575	362	2.2	336	4.0	316	5.9	299	7.7	284	9.6	271	11.4	12	228
		1,400	970	5.3	944	9.8	925	14.3	908	18.8	893	23.3	880	27.8	15	793
		2,050	1,450	7.7	1,424	14.3	1,404	20.9	1,387	27.5	1,373	34.1	1,359	40.7	16	1,256
RAI 718	8	575	600	3.3	563	6.3	534	9.3	510	12.3	489	15.4	470	18.4	10	446
		1,400	1,590	8.1	1,553	15.4	1,524	22.7	1,500	30.1	1,479	37.4	1,460	44.7	12	1,398
		2,050	2,370	11.9	2,333	22.6	2,304	33.3	2,280	44.0	2,259	54.8	2,240	65.5	12	2,178
RCS 624J	8	1,170							1,007	25.4			922	37.5	13.5	727
		1,508							1,407	33.9			1,321	49.3	14.2	1,096
		1,750							1,693	40.0			1,608	57.8	14.6	1,365
		1,850							1,812	42.4			1,726	61.2	14.8	1,474
		2,124							2,136	50.0			2,051	71.5	15.0	1,787
		2,437							2,507	59.2			2,421	83.6	15.0	2,158
		3,000							3,173	77.6			3,088	107.3	15.0	2,823
RCS 817J	10	980							1,137	28.0			1,050	41.3		
		1,170							1,433	34.1			1,346	49.8	12	1,214
		1,300							1,636	38.4			1,549	55.8	12	1,416
		1,560							2,040	46.8			1,954	67.6	15	1,686
		1,770							2,368	55.0			2,280	78.5	16	1,962
		1,875							2,532	59.2			2,445	84.0	16	2,125
		2,010							2,742	64.6			2,655	91.1	16	2,335
		2,250							3,116	75.6			3,028	105.0	16	2,707
RCS 821		1,170							1,720	40.8			1,616	59.6	12	1,459
		1,560							2,450	55.9			2,345	80.9	15	2,023
		1,875							3,039	70.7			2,934	100.5	16	2,551
		2,150							3,553	84.6			3,448	118.4	16	3,064

[1]BHP is the required broke horsepower.

The capacity of seed droppers depends upon their length, flight-wheel diameter, and speed and upon the methods used to seal and feed them. Droppers fed continuously will have more capacity than those fed in pulses from a seed scale. Capacities of cottonseed droppers are given in table 6–24.

Valves and Discharges

Valves that are not well fitted for small-pipe systems can give trouble. For lines containing vane-type seed valves, the takeoff angle should not exceed 30 degrees. The deflector vane should be of adequate thickness and should be well fitted into the body of the valve, with the seated end adjusted to prevent chokage by lint or by seed buildup at the valve intake.

The discharge funnel directs the flow of air and seed through the pipe and into open bins. This flow, however, should not be directed toward a wall or any obstacle that might cause the seed to crack.

Weighing Equipment

A common device for weighing cottonseed is a pocket wheel that receives the seed and dumps automatically when each pocket of the wheel contains a specified weight. A counter is triggered each time the seed pocket dumps. Frequent calibration and maintenance of the pocket wheel are critical. These may be done by catching and weighing several dumps during normal ginning.

Electronic belt scales are also available for weighing seed. They are generally very accurate but are more expensive and require technical personnel to keep them calibrated and maintained.

Temporary Storage

Temporary seed storage is usually accomplished by conveying seed to an overhead hopper-bottom house of sufficient height to clear the top of a trailer truck (fig. 6–30). These houses have bottoms sloped at 45°–60° so that they will empty by gravity when the slide gate is opened. Electric vibrators are sometimes used on the sloping sides to reduce the tendency for seed to bridge in the openings. Overhead capacities are normally about 90 tons/unit. Large gins may have several units.

Because overhead houses allow rapid loading into open-top trailers, these houses are often used to stage seed for shipment from long-term storage on the gin yard. Normally, the houses are filled by a blower system coupled with a loader hopper and feed system. The loader hopper should have a capacity equal to approximately two times the loader bucket's volume. A powered agitator should be used to meter seed into a vacuum wheel. These systems are also used to blow seed directly into a trailer or boxcar. Most storage house emptying systems have a minimum capacity of 20 tons/hr.

Table 6–24.
Capacities of cottonseed droppers

Diameter (inches)	Drive horsepower	Length (inches)	Capacity lb/min	Capacity tons/hr	Capacity bales/hr
12[1]	3	18	350	10	25
16[2]	1	12	235	7	18
	2	18	352	11	26
	3	24	470	14	35
22[2]	3	12	435	13	32
	5	18	652	20	50
	7.5	24	870	26	65
	10	36	1,305	39	98

[1]Operated at 70 rpm.
[2]Operated at 55 rpm.

Figure 6–30. Typical overhead cottonseed storage house having a hopper bottom

If a front-end loader has a high enough lift capability and the building is tall enough, seed may be loaded directly into open-top trailers. Belt conveyors, loaded either manually or mechanically, can also be used. Closed van trailers can be loaded by extending a horizontal portion of the belt conveyor into the trailer.

Walking-floor trailers are becoming more common in trucks that haul cottonseed. These floors will unload seed at ground level behind the trailer without requiring other handling equipment.

Long-Term Storage

Dry, cool seed and sufficient aeration are the keys to minimizing storage losses and quality deterioration. At ginning, cotton may have a seed moisture content as low as 6 percent or as high as 18 percent, but the majority will be within the 10–15 percent range. With proper aeration, seed having a moisture content below 19 percent can be successfully stored. However, cottonseed for planting should not be stored with a moisture content above 12 percent.

Seed is usually highest in moisture at the beginning and end of the harvest season. Most ginners send their high-moisture seed to the oil mill for immediate processing and put the drier seed into long-term storage.

Buildings

Most cottonseed storage facilities have moistureproof concrete floors. The structural framing may be either wood or steel, and the outside is usually clad with sheet metal. Lining with 3/4-inch plywood helps prevent damage to the outside building walls, facilitates clean out, increases wall strength, and reduces settling pressure on exposed purlins.

Three types of buildings are commonly used to store cottonseed at gins: rectangular storage buildings, Quonset huts, and Muskogee-type buildings. The commercial, rectangular metal building (or flat storage building) is the most popular new construction. Some flat storage buildings exceed 80 ft in width, but 60-ft widths are more common. A few gins have bought used Muskogee houses complete with an aeration system.

Floor loads from seed alone will be approximately 700 lb/ft^2 for a 20-ft seed depth. Floors should have sufficient concrete and reinforcement to support a loaded 60,000-lb truck.

Buildings used to store cottonseed must be designed to withstand lateral forces. Lateral wall forces for flat-top storage of cottonseed can be estimated by the following formula:

$WF = KA \times D \times H$,

where

WF = horizontal wall force (lb/ft^2),
KA = active pressure coefficient (.17 to .20 when an angle of repose of 45° is used),
D = density = weight/ft^3 = 28 lb/ft^3, and
H = height or seed depth.

When the preceding formula is used, the lateral pressure at the base of a 20-ft seed depth would be 168 lb/ft^2. Due to boundary effects of the floor, maximum force and wall failure usually occur at 10–20 percent of wall height above the floor. Walls should be designed to include a safety factor and to accommodate front-end loader pressure against them. When existing buildings are converted for cottonseed storage, the walls should be analyzed and strengthened as needed before filling with seed.

Quonset huts or other steel buildings built with 4- to 8-ft-high sidewalls of adequate strength eliminate much of the potential for front-end loader damage.

Aeration

Long-term cottonseed storage facilities must be equipped with an aeration system. Most aeration systems are designed so that the air flows downward through the cottonseed to prevent tunneling and to help minimize moisture accumulation in the top layers of seed. If the airflow is upward, the top layer of seed may become moist as warm, moist air moves upward into the cooler top layers of seed. Downward airflow also counteracts any natural convectional air movement. The temperature and odor of the exhaust air from the fan can give an indication of cottonseed condition.

A safe airflow rate for aerating cottonseed in flat storage is 10 ft^3/min/ton. At this rate, cottonseed with as much as 15 percent moisture can be safely stored. Drier seed and well-managed storage facilities do not require such a fast airflow rate. Well-designed installations may require an aeration rate of only 5 ft^3/min/ton.

Static pressure losses from cottonseed depths ranging from 10 to 30 ft are given in table 6–25. In large Muskogee-type storage buildings, cottonseed depth usually limits the amount of air that can be economically moved. For example, when cottonseed is 80 ft deep and the airflow rate is 2 ft^3/min/ton, the static pressure is approximately 20 inches of water (fig. 6–31).

Usually no additional aeration is necessary once the seed has cooled to the desired temperature. The safe temperature for long-term storage is about 60 °F. Even so, seed temperatures should be monitored throughout the storage period, since hot spots occasionally develop. Usually a few hours of additional aeration will remove the heat from the trouble spot. Many seed storage

Table 6–25.
Resistance of cottonseed to airflow in flat storage buildings

Depth of cottonseed (ft)	Airflow rate (ft^3/min/ton)	Static pressure losses (inches H_2O)	Horsepower required (per 100 tons)
10	5	1.0	0.1
	7.5	1.1	.2
	10	1.6	.4
12	5	1	.1
	7.5	1.6	.35
	10	2.3	.65
14	5	1.3	.16
	7.5	2.1	.6
	10	3.1	1.2
16	5	1.7	.22
	7.5	2.8	.6
	10	4.0	1.2
18	5	2.2	.29
	7.5	3.5	.75
	10	5.0	1.50
20	5	2.7	.37
	7.5	4.5	.9
	10	6.3	1.7
22	5	3.3	.46
	7.5	5.3	1.1
	10	7.7	1.9
24	5	4.1	.55
	7.5	6.4	1.4
	10	9.5	2.5
26	5	4.7	.66
	7.5	7.6	1.6
	10	11.4	2.9
28	5	5.5	.78
	7.5	9	1.7
	10	13.5	3.4
30	5	6.3	.9
	7.5	10.1	2.0
	10	15.5	3.9

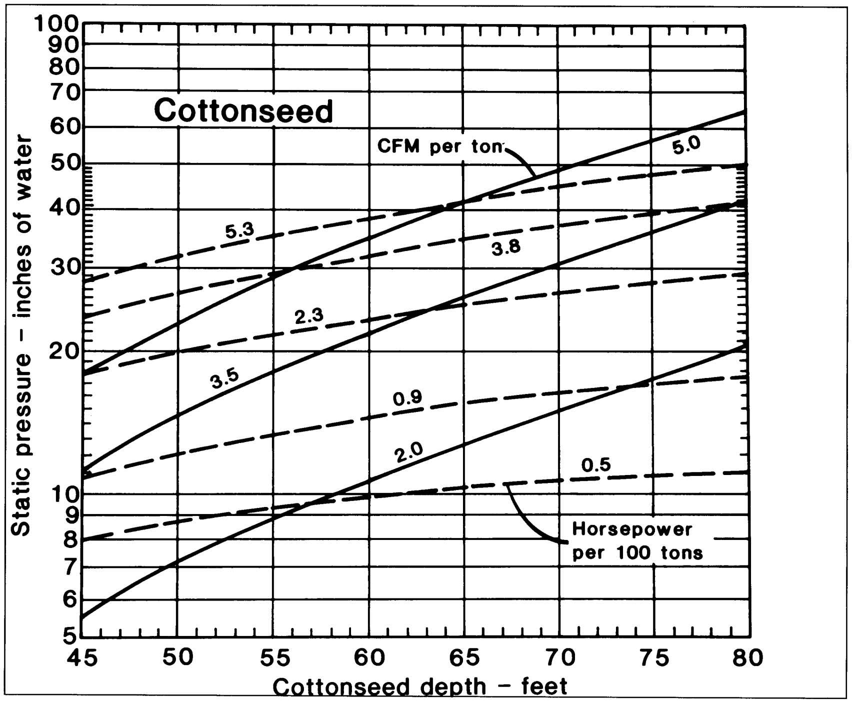


Figure 6–31. Fan horsepower and static pressure requirements for aerating cottonseed in Muskogee-type storage buildings. *CFM*, cubic feet per minute.

facilities are equipped with temperature-monitoring systems. Seed temperature should be monitored by inserting thermocouple probes attached to steel rods or electrical conduit into the seed. Odors and temperatures of exhaust air should be monitored as an indication of overall condition of the seed.

Design of Aeration Systems

Aeration systems have four principal parts that must be properly designed: (1) aeration ducts to move air out of the cottonseed, (2) supply pipes to transport the air, (3) fans to supply the required volume of air at a specific static pressure, and (4) motors to drive the fans.

Aeration Ducts

Two important design criteria for a cottonseed aeration duct are (1) to provide adequate duct surface area and (2) to provide adequate cross-sectional area. Aeration ducts may be any shape, but their open surface area should be at least 10 percent of the total duct surface area. Within a duct, pressure losses can be held to a minimum by limiting the velocity of the air leaving the cottonseed through the duct (face velocity) to 10 ft/min.

For cottonseed depths up to 25 ft, the air velocity within a duct should range from 1,500 to 2,000 ft/min. For duct lengths less than 10 ft, velocities up to 2,500 ft/min are acceptable.

Ducts on the floor of a seedhouse should be spaced to keep the airflow path to all ducts as equal as possible. Thus, duct spacing should not exceed 1-1/2 times the depth of the cottonseed.

Ducts can be installed along the length or width of a storage facility. Ducts across the width are preferred because they provide better airflow distribution and allow aeration to start as soon as the first duct is covered with seed. Also, widthwise ducts allow the airflow to be concentrated in selected areas to remove hot spots that sometimes develop.

Supply Pipes

Pipes should be designed to transport air from the ducts to the fan at a velocity of 3,000–4,000 ft/min. Pipe size can be determined from table 6–26.

Fans and Motors

Before a fan and motor are selected, the static pressure and the required volume of air to aerate the number of tons of seed must be known. Static pressure depends on the depth of seed (table 6–25, fig. 6–31). Once the volume and static pressure are known, a fan and motor can be selected from manufacturers catalogs.

Aeration Examples

The following are examples of two typical cottonseed aeration systems:

EXAMPLE 1. A ginner wishes to store 1,200 tons of cottonseed on the gin yard. A small-pipe seed-handling system will be used to put the cottonseed into storage, and the seed will be unloaded with a front-end loader. The design of the storage building and aeration system should be as follows:

1. Building
   - A. Dimensions of storage structure: 60 ft wide, 100 ft long; eave clearance of 18 ft to accommodate the front-end loader.
   - B. Cottonseed depth: 16 ft.
   - C. Building length: 120 ft, enough to provide access for unloading without requiring a bulkhead door.

2. Aeration System
   - A. System capacity: 1,200 tons of cottonseed.
   - B. Airflow rate: 10 ft^3/min/ton.
   - C. Total air volume needed: 1,200 tons X 10 ft^3/min/ton = 12,000 ft^3/min.
   - D. Duct layout: shown in figure 6–32.
   - E. Duct size: each duct carries 1/5 of the total volume of air (2,400 ft^3/min). For a maximum air velocity of 2,000 ft/min, the duct cross-sectional area should be 1.2 ft^2. This could be attained by using a 15-inch round duct or a 21-inch half-round duct (table 6–27) or a 1.2 ft by 1 ft rectangular duct.
   - F. Duct surface area: total surface area needed for a 10 ft/min face velocity is 240 ft^2 (2,400 CFM/10 ft/min) or 240 ft^2/50 ft of duct, which equals 4.8 ft^2/ linear foot. This may be achieved with an 18-inch round duct, a 36-inch half-round duct, or a 57-inch-wide by 4-inch-deep flat (in-floor) duct.
   - G. Diameter of supply pipes: 12 inches. Each duct carries 1/5 of the total volume of air (or 2,400 ft^3/min/duct). From table 6–26 we can see

Table 6–26.
Air-carrying capacities for supply pipes and manifolds

Pipe diameter (inches)	Cross-sectional area (ft^2)	Air-carrying capacities (ft^3/min) at velocity of: 2,000 ft/min	3,000 ft/min	4,000 ft/min
5	0.136	272	408	544
6	0.196	392	588	784
7	0.267	534	801	1,068
8	0.349	698	1,047	1,396
9	0.442	884	1,326	1,768
10	0.545	1,090	1,635	2,180
11	0.66	1,320	1,980	2,640
12	0.785	1,570	2,355	3,140
13	0.922	1,844	2,766	3,688
14	1.069	2,138	3,207	4,276
15	1.227	2,454	3,681	4,908
16	1.396	2,792	4,188	5,584
17	1.576	3,152	4,728	6,304
18	1.767	3,534	5,301	7,068
19	1.969	3,938	5,907	7,876
20	2.182	4,364	6,546	8,728
21	2.405	4,810	7,215	9,620
22	2.64	5,280	7,920	10,560
23	2.885	5,770	8,655	11,540
24	3.142	6,284	9,426	12,568
25	3.409	6,818	10,227	13,636
26	3.687	7,374	11,061	14,748
27	3.976	7,952	11,928	15,904
28	4.276	8,552	12,828	17,104
29	4.587	9,174	13,761	18,348
30	4.909	9,818	14,727	19,636
31	5.241	10,482	15,723	20,964
32	5.585	11,170	16,755	22,340
33	5.939	11,878	17,817	23,756
34	6.305	12,610	18,915	25,220
35	6.681	13,362	20,043	26,724
36	7.068	14,136	21,204	28,272

Table 6–27.
Air-carrying capacities for round aeration ducts

Pipe diameter (inches)	Cross-sectional area (ft^2)	Air-carrying capacities (ft^3/min) at velocity of: 1,500 ft/min	2,000 ft/min
5	0.136	204	272
6	0.196	294	392
7	0.267	401	534
8	0.349	521	698
9	0.442	663	881
10	0.545	818	1,090
11	0.660	990	1,320
12	0.785	1,178	1,570
13	0.922	1,383	1,844
14	0.069	1,604	2,138
15	1.227	1,811	2,451
16	1.396	2,094	2,792
17	1.576	2,364	3,152
18	1.767	2,651	3,534
19	1.969	2,954	3,938
20	2.182	3,273	4,364
21	2.405	3,608	4,810
22	2.640	3,960	5,280
23	2.885	4,328	5,770
24	3.142	4,713	6,284
25	3.409	5,114	6,818
26	3.687	5,513	7,374
27	3.976	5,964	7,952
28	4.276	6,414	8,552
29	4.587	6,881	9,174
30	4.909	7,364	9,818

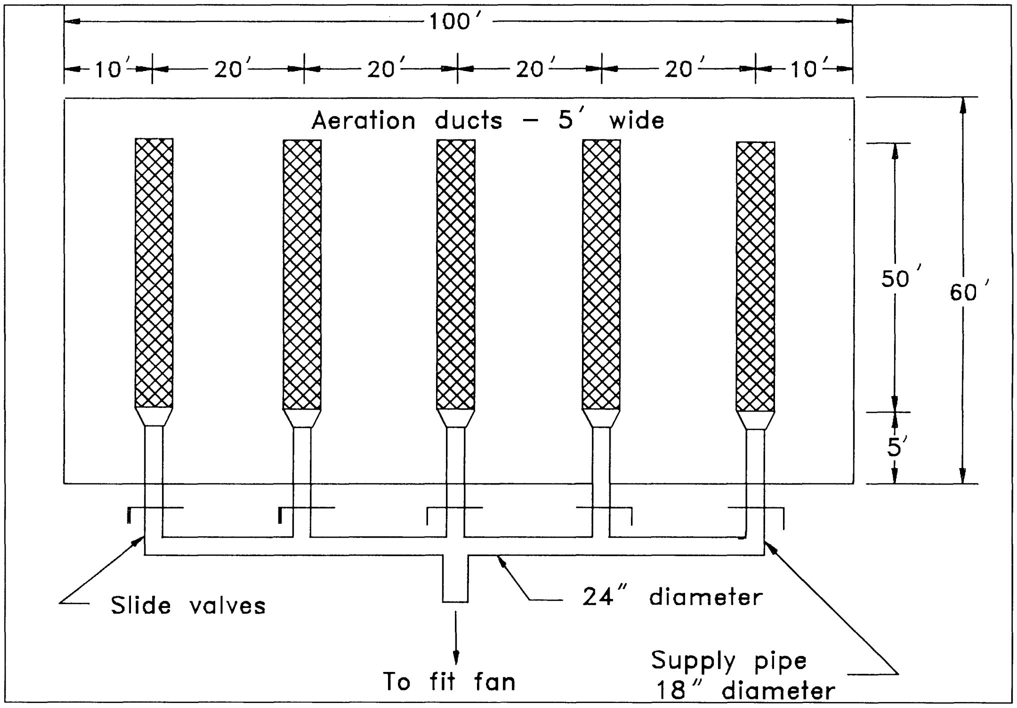


Figure 6–32. Aeration duct layout for 1,200-ton cottonseed storage building

that a supply pipe 12 inches in diameter will carry up to 2,355 ft^3/min (which is close enough for this case) at a velocity of 3,000 ft/min.

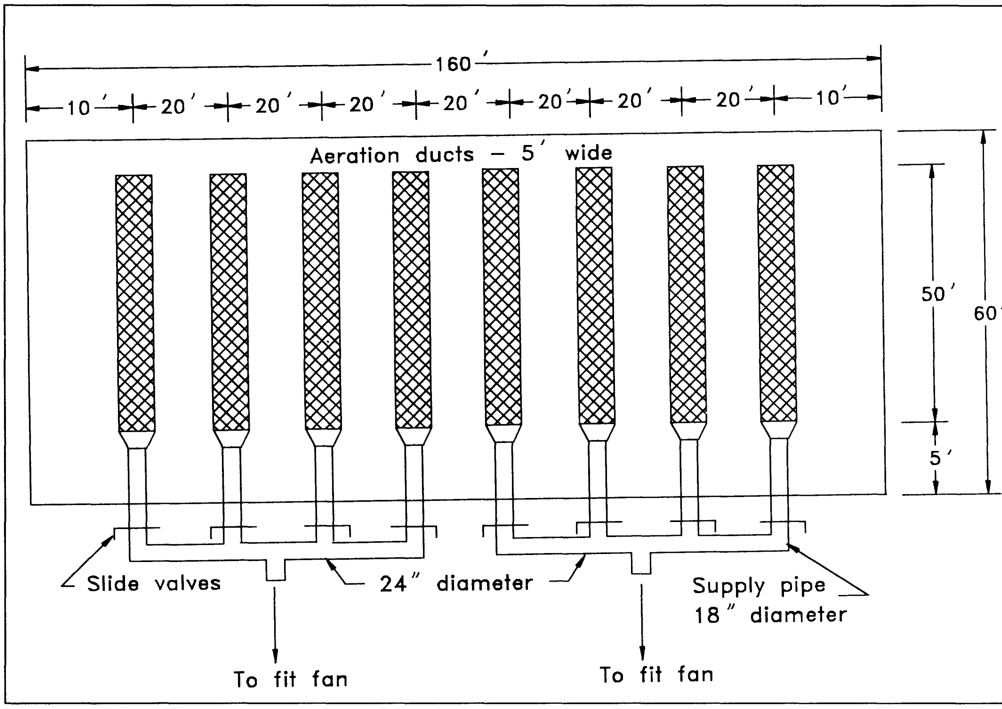
H. Diameter of manifold pipes: 18 inches. The manifold pipe carries air for two supply pipes (or 4,800 ft^3/min). From table 6–26, we can see that an 18-inch-diameter pipe will carry up to 5,301 ft^3/min at a velocity of 3,000 ft/min.

I. Fan and motor: At a cottonseed depth of 16 ft and an airflow rate of 10 ft^3/min/ton, the static pressure to be overcome by the fan is 4.0 inches of water (table 6–25). From a manufacturers catalog, select a centrifugal fan that can deliver at least 12,000 ft^3/min at 4 inches static pressure. Such a fan is likely to have a wheel diameter of 27 inches, to operate at 1,400 rpm, and to have a 15-hp motor.

EXAMPLE 2. A ginner wishes to store 2,000 tons of cottonseed on the yard. Seed will be loaded into the storage house with a small-pipe handling system and will be unloaded with a front-end loader. The design of the storage building and aeration system should be as follows:

1. Building
   A. Dimensions of storage structure: 60 ft wide, 160 ft long; eave clearance of 18 ft.
   B. Average cottonseed depth: 17 ft.
   C. Building length: 180 ft, enough to allow access for unloading.

Figure 6–33. Aeration duct layout for 2,000-ton cottonseed storage building



2. Aeration System
   A. System capacity: 2,000 tons of cottonseed.
   B. Airflow rate: 10 ft^3/min/ton.
   C. Total air volume required: 2,000 tons × 10 ft^3/min/ton = 20,000 ft^3/min.
   D. Duct layout: shown in figure 6–33.
   E. Duct size: Each duct carries 1/8 of the total air volume (1/8 of 20,000 ft^3/min = 2,500 ft^3/min). For a maximum air velocity of 2,000 ft/min, the duct cross-sectional area should be 1.25 ft^2. This could be attained by using a 15-inch round duct or a 22-inch half-round duct (table 6–27) or a 1.25 ft by 1.0 ft rectangular duct.
   F. Duct surface area: total surface area needed for a 10 ft/min face velocity is 250 ft^2 (2,500 CFM/10 ft/min) or 250 ft^2/50 ft of duct, which equals 5 ft^2/ linear foot. This may be achieved with a 20-inch round duct, a 38-inch half-round duct, or a 5-foot-wide by 4-inch-deep flat (in-floor) duct.
   G. Diameter of supply pipes: 13 inches. Each duct carries 1/8 of the total air volume (or 2,500 ft^3/min). Using table 6–26, we can see that a 13-inch diameter pipe is needed to carry this volume at 3,000 ft^3/min.
   H. Diameter of manifold pipes: 18 inches. Each pipe must handle 5,000 ft^3/min. Table 6–26 shows that an 18-inch pipe can handle a volume of 5,301 ft^3/min at a velocity of 3,000 ft/min.
   I. Fans and motors: At a cottonseed depth of 17 ft and an airflow rate of 10 ft^3/min/ton, the static pressure to be overcome is 4.5 inches of water (table 6–25, interpolate between 16- and 18-ft depths). From a

manufacturers catalog, select two centrifugal fans that can each deliver at least 10,000 ft^3/min at 4.5 inches static pressure. These fans are likely to have wheel diameters of 27 inches, to have 10-hp motors, and to operate at 1,370 rpm.

Managing Aeration Systems

Good judgment should be used in selecting cottonseed to store. Cottonseed should not be stored if it is from cotton picked in the early morning after a heavy dew or picked soon after a rain or snow. Seed from cotton that may have gotten wet on a trailer or module should also not be stored. The cottonseed moisture content should not exceed 12 percent if the seed will be stored at temperatures above 60 °F; however, the moisture content can be as high as 15 percent if the seed temperature is reduced to 50–60 °F during storage.

Being hygroscopic, cottonseed will absorb moisture from or give up moisture to its surrounding air. Therefore, aeration fans should not be operated during high humidity periods or during rain or fog. Ideally, cottonseed in storage should be cooled to 50–60 °F by selecting cool, dry days to run the fans.

References

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Rayburn, S.T., G.N. Franks, and C.S. Shaw. 1977. Cottonseed handling. *In* Cotton Ginners Handbook, pp. 69–72. U.S. Department of Agriculture, Agricultural Handbook 503.

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SECTION 7— A COMPREHENSIVE GIN MAINTENANCE PROGRAM

T.K. Keilty

The success and profitability of a ginning operation is determined by the effectiveness of its machinery maintenance program. A comprehensive gin maintenance program impacts safety, fiber quality, daily and annual volume, downtime, energy costs, and maintenance costs (material and labor).

A good gin maintenance program involves continual documentation, communication, and planning. Each employee must communicate the needs and benefits of the program. The office worker compiling the repair and downtime data, the gin crew performing the preventive maintenance and cleaning the gin, the ginner troubleshooting problems and operating the gin, the superintendent troubleshooting problems and planning repairs, and the gin manager overseeing the entire operation while satisfying the customers' needs of timely, quality ginning, all must become part of the gin repair process.

A comprehensive gin maintenance program has four basic components:

1. A sound maintenance philosophy
2. Problem and repair documentation and guidelines
3. A dormant season repair program
4. A preventive maintenance and in-season repair program.

Sound Maintenance Philosophy

For a comprehensive effective repair program, management must adopt and communicate to all employees a sound, year-round philosophy. That philosophy is simply that in order to reduce seasonal downtime, a gin must be repaired properly the first time.

Repair Documentation and Guidelines

The repair, downtime, and preventive maintenance history must be tracked and used in planning the needed dormant season repairs and justifying machinery modifications. The maintenance reports provided in the next three sections are only for illustrative purposes and may be useful in a maintenance program. The most important thing is documentation of the gin's performance, the individual machinery problems, and the type of gin repairs. Written guidelines should emphasize management's commitment to quality repair and should direct activities of seasonal employees who are unfamiliar with the operation of a gin. Guidelines for a sound repair program during the ginning season include the following:

1. Keep the gin clean and safe.
2. Perform inspections by competent employees trained in detecting problems before they cause lengthy shutdowns.

3. Perform preventive maintenance (P.M.) on a routine basis.

4. Shut down the gin (if possible) before making repairs.

5. Take time to think about how to do the repair safely.

6. Have the crew perform P.M. work elsewhere if the gin is shut down for a repair.

7. Have an adequate supply of parts on hand for repairs.

8. Repair machinery properly the first time.

9. Maintain a log of downtime for all repairs (fig. 7–1) and a log of maintenance performed (fig. 7–2).

Guidelines for a repair program during the dormant season include the following:

1. Keep the gin clean and safe (lock out power to a machine before working on it).

2. Follow the manufacturer's specifications when repairing machinery.

3. Spend the money to make repairs properly so that seasonal downtime is reduced.

4. Repair machinery that might otherwise not make it through the season.

5. Plan ahead to have repair tools and parts on hand.

Dormant Season Repairs

A dormant season repair program should enable the ginner to make repairs in an organized and thorough manner, thus minimizing seasonal downtime. A team consisting of the ginner, superintendent, and manager should be involved in planning repairs. All information from the P.M. reports and downtime reports can be compiled (fig. 7–3 shows an example) and used to determine trouble spots within the systems.

The team should have guidelines for checking each machine and a list for all the parts that may be needed for repairing each machine (example guidelines and parts list for a lint cleaner are shown in figs. 7–4 and 7–5, respectively). The team should start at one end of the gin and systematically work their way through the gin, inspecting each machine one by one. After inspection, the team can determine the cost of the repairs and should determine if the repairs indicated on the repair checklist will solve the problems identified on the downtime report. Repair checklists will allow the ginner to obtain, in one purchase, all the parts needed for the machines requiring repair. With these parts in hand, the ginner can concentrate on repairing one or two machines at a time without waiting for delivery of repair parts.

In making any repair, particular care should be taken to ensure that speeds and adjustments are set according to the manufacturer's recommendations. Manufacturer's parts instructions and maintenance books provide all the information necessary to make the proper adjustments.

Preventive Maintenance (P.M.)

The success of a ginning operation is determined by how efficiently the cotton is ginned. The gin should be properly repaired and ready to operate at maximum efficiency with minimum downtime. The basic principle of P.M. is the reduction of downtime through the scheduling of routine maintenance and repairs. Preventive maintenance will reduce repair costs while increasing daily production. Repair costs are reduced by doing small repairs on the machinery before larger problems occur as other components are impacted. The larger problems require more downtime and cause more expensive repairs.

Preventive maintenance should be scheduled once during each operating shift. If a gin is operating 12 hr/shift, 1 hr should be devoted to preventive maintenance. All members of the crew must participate and have certain machinery for which they are always responsible. After all machinery is safely locked out and proper safety instructions are given, the ginner should assign each employee to certain machinery, give each of them a preventive maintenance checklist (fig. 7–6), and train each in what to look for. After the initial training period, the ginner will be able to concentrate on specific repair problems needing specialized attention. If a problem is discovered during the P.M. period, the problem should be corrected immediately. If the parts or necessary pieces of equipment are not available to repair the machinery immediately, the parts should be ordered and the repair scheduled for the next P.M. period.

P.M. is an ongoing process, and the procedures to be followed depend partly on the period of gin operation. The three periods and the procedures for each period are as follows:

1. After initial break-in period (72 hr):
   a. Lock out all equipment.
   b. Check condition and alignment of pulleys, belts, sprockets, and chains. Check the tension on belts and chains. Tighten all set screws and bolts used in obtaining and holding the proper alignment on sprockets and sheaves.
   c. Check for adequate or excessive lubrication.
   d. Check general appearance and condition of parts; tighten and adjust as necessary.
   e. Check entire system for excessive wear and tagging that could cause choking.

f. Check for evidence of loose connections or leaks in the duct system.
g. Check electrical wiring for evidence of arcing and insulation breakdown.
h. Check interiors of all machines for chokes or cotton accumulations.

2. During each production run:
   a. Observe the entire gin for a smooth, orderly flow of cotton with even distribution across the machinery.
   b. Listen for excessive noise or vibration.
   c. Listen for chattering of gears, shafts, chains, and motors.
   d. Check for evidence of worn bearings.
   e. Observe chains and sprockets for proper alignment, and check tension on chains.
   f. Check for visible signs of overlubrication.
   g. Observe belt and pulley movement for proper alignment and tension.
   h. Check idler sprockets and pulleys for proper tension and alignment.
   i. Check air handling systems for leaks or loose connections.
   j. Check trash for excessive cotton (both seed cotton and lint cleaner trash).
   k. Check hydraulic systems for leaks, overheating, or choked filters.
   l. Check seed for excessive lint and for damage.
   m. Check final lint sample for evidence of poor machine conditions (poor preparation, excess trash, seed coat fragments and neps).

3. Between production runs:
   a. Lock out all equipment.
   b. Check interiors of receiving condensers for choking conditions.
   c. Check the inlets, outlets, trash discharge, and interiors of all equipment for tags, trash accumulations, and worn or damaged parts that could result in choking, loss of cotton, or reduced efficiency.
   d. Check equipment for dirt and excessive lubrication.
   e. Check moving parts for evidence of excessive wear, such as grooving, chafing, and binding.
   f. Check the condition and tension of pulleys, belts, chains, and sprockets.
   g. Check for bent or missing grid bars.
   h. Check for missing or bent spikes on cylinder cleaners.
   i. Check vacuum wheel and condenser flashing.

During the P.M. process the ginner must have a method of documenting the amount of work needed on each machine. The report in figure 7–2 may be used for this purpose. The information in the P.M. reports may help determine which dormant season repairs and machinery modifications are necessary.

Figure 7–1. Downtime report

Downtime Report

Equipment	Code	Downtime Hours	Reason Code	Bypass	Reason Code
Telescopes	0001	____.____	_____	________	1 Belts/Sheaves
Separator	0002	____.____	_____	________	2 Bearings/Housings
Vacuum Wheel	0003	____.____	_____	________	3 Sprockets/Spur Gear
Automatic Feed	0004	____.____	_____	________	4 Screen/Grids
Tower Dryer/Super Vol.	0005	____.____	_____	________	5 Saws/Rolls
Thermo Dryer	0006	____.____	_____	________	6 Shafts
Hot-Air Cleaner	0007	____.____	_____	________	7 Flashing
Stick Machine	0008	____.____	_____	________	8 Scrolls
Dirt Vacuum Wheel	0009	____.____	_____	________	9 Pipe Work
Gravity Cleaner	0010	____.____	_____	________	10 Brushes
Burr Extractor	0011	____.____	_____	________	11 Ribs
Distributor	0012	____.____	_____	________	12 Bushings
Overflow Sep.	0013	____.____	_____	________	13 Feed Control
Auto Overflow	0014	____.____	_____	________	14 Rollers
Feeder	0015	____.____	_____	________	15 Motor Burnout
Gin Stands	0016	____.____	_____	________	16 Other Electrical
Super Jets	0017	____.____	_____	________	17 Hydraulics
Moss Lint Cleaner	0018	____.____	_____	________	18 Chokeups
Comber/L.S. Clnr.	0019	____.____	_____	________	19 Fire
Lummus 66 Lint Clnr.	0020	____.____	_____	________	20 Conveyors
Lummus 86 Lint Clnr.	0021	____.____	_____	________	21 Bypass
Battery Cond.	0022	____.____	_____	________	22 Air Cylinders
Lint Chg. System	0023	____.____	_____	________	23 Other
Augers/Conveyors	0024	____.____	_____	________	**Miscellaneous Reasons**
Tramper	0025	____.____	_____	________	24 Out of Cotton
Press	0026	____.____	_____	________	25 Weather
Bale Hndlg. System	0027	____.____	_____	________	26 Tractor/Bale Wagon
Press Pump	0028	____.____	_____	________	27 Labor Shortage
Mote System	0029	____.____	_____	________	28 Power Failure
Burners	0030	____.____	_____	________	29 Mistagged Bales
Fans	0031	____.____	_____	________	30 Trash Hauling
Seed System	0032	____.____	_____	________	31 Cotton Switch
Cyclone/Scrn. Basket	0033	____.____	_____	________	32 Module Truck
Module Feeder	0034	____.____	_____	________	
Other	0035	____.____	_____	________	
Misc. Reason	0000	____.____	_____	________	

Figure 7–2. Preventive maintenance report

Preventive Maintenance Report

Gin Location:______________________________ Shift:______________

Date:______________ Ginner's Name:______________________________

Equipment	Code	Man Hours	Reason Code	Reason Code
Telescopes	0001	______	______	1 Belts/Sheaves
Separator	0002	______	______	2 Bearings/Housings
Vacuum Wheel	0003	______	______	3 Chain Sprockets/Spur Gear
Automatic Feed	0004	______	______	4 Screen/Grids
Tower Dryer/Super Vol.	0005	______	______	5 Saws/Rolls
Thermo Dryer	0006	______	______	6 Shafts
Hot-Air Cleaner	0007	______	______	7 Flashing
Stick Machine	0008	______	______	8 Scrolls
Dirt Vacuum Wheel	0009	______	______	9 Pipe Work
Gravity Cleaner	0010	______	______	10 Brushes
Burr Extractor	0011	______	______	11 Ribs
Distributor	0012	______	______	12 Bushings
Overflow Sep.	0013	______	______	13 Feed Control
Auto Overflow	0014	______	______	14 Rollers
Feeder	0015	______	______	15 Motor Burnout
Gin Stands	0016	______	______	16 Other Electrical
Super Jets	0017	______	______	17 Hydraulics
Moss Lint Cleaner	0018	______	______	18 Chokeups
Comber/L.S. Clnr.	0019	______	______	19 Fire
Lummus 66 Lint Clnr.	0020	______	______	20 Conveyors
Lummus 86 Lint Clnr.	0021	______	______	22 Air Cylinders
Battery Cond.	0022	______	______	23 Other
Lint Chg. System	0023	______	______	26 Tractor/Bale Wagon
Augers/Conveyors	0024	______	______	33 Grease
Tramper	0025	______	______	34 Cleaning
Press	0026	______	______	35 Adjustments
Bale Hndlg. System	0027	______	______	
Press Pump	0028	______	______	
Mote System	0029	______	______	
Burners	0030	______	______	
Fans	0031	______	______	
Seed System	0032	______	______	
Cyclone/Scrn. Basket	0033	______	______	
Module Feeder	0034	______	______	
Other	0035	______	______	
Misc. Reason	0000	______	______	

Figure 7–3. Example summary of preventive maintenance and downtime

Equipment and reason	Downtime (hours)				P.M. time (hours)				Total freq.
	Freq.	Shift 1	Shift 2	Shift 3	Freq.	Shift 1	Shift 2	Shift 3	
00 None									
19 Fire	1	1.0	0.0	0.0		0.0	0.0	0.0	1
23 Other	1	3.5	.0	.0		.0	.0	.0	1
25 Power Failure	4	2.5	.0	.0		.0	.0	.0	4
29 Mistagged Bales	1	2.0	.0	.0		.0	.0	.0	1
30 Trash Hauling	3	6.0	.0	.0		.0	.0	.0	3
01 Telescopes									
17 Hydraulics	0	.0	.0	.0	1	.5	.0	.0	1
02 Separator									
02 Bearings/Housings	0	.0	.0	.0	1	1.0	.0	.0	1
03 Sprockets/Gears	0	.0	.0	.0		2.0	.0	.0	1
16 Other Electrical	1	1.0	.0	.0		.0	.0	.0	1
13 Chokeups	1	.5	.0	.0		.0	.0	.0	1
03 Vacuum Wheel									
13 Sprockets/Gears	1	.0	1.0	.0		.0	.0	.0	1
04 Automatic Feed									
13 Feed Control	1	.5	.0	.0	1	2.0	.0	.0	2
05 Tower Dry/Sup VD									
13 Chokeups	1	.5	.0	.0		.0	.0	.0	1
34 Repair Time Off	0	.0	.0	.0	15	3.4	.0	.0	15
07 Hot-Air									
01 Belts/Sheaves	0	.0	.0	.0	1	.5	.0	.0	1
02 Bearings/Housings	0	.0	.0	.0	1	1.0	.0	.0	1
03 Sprockets/Gears	0	.0	.0	.0	1	.1	.0	.0	1
06 Shafts	3	1.5	4.5	.0	1	2.0	.0	.0	4
14 Rollers	0	.0	.0	.0	1	3.0	.0	.0	1
18 Chokeups	3	1.5	.0	.0		.0	.0	.0	3
19 Fire	0	.0	.0	.0	1	.0	4.0	.0	1
21 Other	0	.0	.0	.0	1	.0	3.0	.0	1

Figure 7–4. Guidelines for checking a lint cleaner for dormant season repair

Lint Cleaner Checklist

Condenser	Check for holes, worn flashing, bent wire, bad bearings, cracked staves, and misalignment
Fluted Doffing Roller	Replace end seal; check wear and flashing
Smooth Doffing Roller	Check tension on roller; replace end seals; check for wear; check flashing
Feed Rollers	Check clearance and tension spring
Feed Bar	Check clearance and check for wear
Grid Bars	Check clearance and check for wear
Saws	Check for tooth damage, dull teeth, and unwinding
Air Doff	Check air gap on doffing hood
Brushes	Check for wear, breaks, and clearance
Windboard	Check air gap
Tension Arm	Check springs
Lights	Check cords, bulbs, and connections
Idler Pulley	Check for wear; make sure pulley is not frozen
Belts	Check for cracking, stretching, and burning
Sheaves	Check alignment and bushings; make sure sheaves are not worn
Chains	Check slack
Sprockets	Check for worn teeth and check bushings
T-flashing	Check for wear and burning
Windows	Check for leaks and for missing or broken windows
Guards	Check for missing or broken guards
Miscellaneous	

Figure 7–5. Parts list and repair checklist for a typical lint cleaner

Parts List and Repair Checklist

Gin Location ________________ Date __________ Page ___ of ___

Lummus 66 Lint Cleaners

Repaired by	Item No.	Parts description	Description of task	Quantity	Cost/ item	Exten- sion
______	079756	Leather end seals				
______	558353	Condenser flash (set)				
______	062141	Condenser screen				
______	559138	Feed roller flashing				
______	181594	Saw cylinder				
______	068072	100W light bulb				
______	032805	Light bulb cover				
______	559112	Wooden staves (set)				
______	488262	1-3/16" flt doff shft				
______	568105	1-3/16" Sta doff shft				
______	550566	Rec. metal staves				
______	550574	Tri. metal staves				
______	014258	B83 Belt				
______	014258	BX53 Belt				
______	014894	BX54 Belt				
______	014878	BX51 Belt				
______	034405	S40 Chain				
______	034421	S60 Chain				
______	003558	Idler Sprkt AC2417				
______	007054	S60–29T 1-15/16" Sprkt				
______	006130	S60–I5T 1-3/16" Sprkt				
______	006270	S60–17T 1-3/16" Sprkt				
______	518746	Idler sprkt combo 24/36T				
______	004465	S40–21T 1-15/16" Sprkt				
______	004697	S40–25T 1-7/16" Sprkt				
______	145656	S60–16T 1-15/16" Sprkt				
______	003442	Idler Sprkt S40–18T				
______	007302	S60–36T 1-3/16" Sprkt				
______	003541	Sprkt AC2318				
______	006676	S60–22T 1-15/16" Sprkt				
______	006049	S60–14T 1-3/16" Sprkt				
______	003491	Idler Sprkt S60–15T				

This equipment has been repaired and is ready for operation. Date: ______________

______________ Ginner ______________ Gin Manager ______________ Superintendent

Figure 7–6. Typical preventive maintenance checklist for a lint cleaner

Preventive Maintenance Checklist for Lummus 66/86 Lint Cleaners

Before doing the following, ***lock out power and let equipment stop.*** Check off each item below when completed.

_______ 1. Check condenser for tagging or choking conditions and then clean condenser.

_______ 2. Clean inside and outside of condenser screen drum.

_______ 3. Check sawteeth and clean them as required.

_______ 4. Remove dust, dirt, and loose matter with high-pressure, moisture-free air.

_______ 5. Check trash pan, ducting, and other internal parts for foreign matter and tagging conditions; remove burrs or other causes of tag.

_______ 6. Inspect and clean rubber parts (gaskets, scale, flashing, etc.).

_______ 7. Check condition and alignment of chains, belts, sheaves, and sprockets. Replace or adjust as necessary.

_______ 8. Clean auxiliary feed roller.

SECTION 8—ENERGY UTILIZATION AND CONSERVATION IN COTTON GINS

W.S. Anthony and Robert C. Eckley

Electricity and fuel energy comprise about 15 percent of the cost of ginning cotton in modern gins. In a survey of 230 Midsouth gins in 1979, Griffin (1980) found that gins consumed about 52 kilowatt-hours (kwh) of electricity and 312 ft^3 of natural gas/bale of cotton ginned. In a similar study in 1987, Anthony (1989) reported that gins required 44 kwh electricity and either 2.3 gal of LP (liquified petroleum) gas or 248 ft^3 of natural gas/bale of cotton. The electricity consumption per bale has remained relatively constant since 1962. Watson and Holder (1964) surveyed 33 gins in 1962 and found that electricity consumption averaged 47.5 kwh/bale for spindle-harvested cotton. Electrical energy requirements among gins usually range from 40–60 kwh/bale. Such a range may occur even among gins that have similar operating capacities.

The cost of energy has risen from $1.75/bale in 1972 to $5.29/bale in 1987—an increase of over 200 percent. The cost of electricity increased from $0.052/kwh in 1975 to $0.091/kwh in 1992. The price of natural gas increased from $0.95/1,000 ft^3 in 1975 to $3.65/1,000 ft^3 in 1992. Thus, energy consumption must be minimized in order to compensate for rising ginning costs.

Fuel (natural or LP gas) consumed in drying constitutes about 64 percent of the total energy used at gins and 20 percent of the energy costs. The amount of fuel consumed in drying varies directly with dryer temperature. It is important to control drying temperature accurately, not only to ensure satisfactory drying but also to avoid excessive drying, which wastes energy and lowers fiber quality. A typical drying system is composed of two centrifugal fans, a burner, a tower dryer, and connecting air lines. Gins usually have two drying systems in their machinery sequence.

Conserving energy in gins requires knowing the energy requirements of different gin processes. In a recent survey of several gins having a capacity of 24 bales/hr, the following data were collected:

Gin process	Connected power required (hp)	Approximate percentage of gin's connected horsepower
Seed cotton handling	505	29.6
Seed cotton cleaning	190	11.1
Ginning	200	11.6
Lint handling	164	9.6
Lint cleaning	165	9.6
Trash handling	160	9.4
Packaging (using a universal density press)	280	16.4
Miscellaneous	45	2.6
Total	1709	100.0

The data on the previous page came from gins having two drying systems. These systems were equipped with burners having a combined heat-generating capacity of 9 million Btu/hr. Seed cotton handling, ginning, and lint packaging accounted for 58 percent of the total connected horsepower.

When the ginning operation was divided into four major processes, the following values were calculated:

Gin process	Connected power required (hp)	Energy per bale		Cost per bale[1]
		kwh	Percent of total	
Cleaning	355	10	19.2	$0.83
Ginning	200	7	13.5	0.58
Packaging	280	4	7.7	0.33
Handling materials	874	31	59.6	2.57
Total	1709	52	100.0	4.31

[1]Based on $0.083/kwh.

Most of the energy cost was associated with handling materials ($2.57/bale), which also required the most power. Ginning required 200 hp and cost $0.58/bale. Packaging required 280 hp but cost only $0.33/bale. Thus, energy costs do not always relate directly to connected horsepower.

The cost of electricity is determined by usage, demand, and power factor. Usage is the amount of energy used per billing cycle and is expressed in kilowatt hours. Demand is the maximum power used during a 15-min period of a billing cycle and is expressed in kilovolt-amperes (kVA). Although rarely needed, this amount of power must be supplied continuously by the utility company. Power factor relates the actual amount of work done to the amount of power drawn from the utility lines at any instant in time. The usage charge is both the largest portion of electrical cost during operation and the one over which the ginner has the most control. A gin manager can hold regular conferences during the ginning season with energy suppliers to get ideas for conservation measures that can be implemented before the next season. If electricity costs $0.07/kwh in a gin using 1,700 hp, every 1 percent of that horsepower wasted in a season will cost about $2,400. If there is little or no advantage to a gin machinery modification after energy wastes are considered, that modification can be rejected before any funds are spent.

Usage patterns can be identified by studying the previous 5 years' billings, which are readily available from energy suppliers. These patterns may be useful in estimating power needs when devising plans to reduce energy costs. For example, if gin A requires 10 kVA for 10 hr/day, then it will use 100 kwh/day. If gin B requires 100 kVA for 1 hr/day, then it will also use

100 kwh/day. However, gin B will probably have a power demand that is about 10 times that of gin A and consequently will pay a greater demand charge.

Demand charges can be influenced by startup procedures. Startup loads are usually about three and four times the connected and operating loads, respectively. Specific types of gin machinery respond differently during startup. For instance, startup times (from 0 to operating speed) vary from 0.5 sec for condensers to 15 sec for lint cleaners. Large motors should be started sequentially, not simultaneously, to allow the startup power surge of a motor to reduce to a normal idle load before starting the next motor. If the motor starts are staggered properly, most gins can be started in less than 2 min without having the starting load exceed the total gin operating load at any instant.

Management can reduce the demand charge. For example, if a gin has both a module feeder and a suction system, each with separate fans, one system can and should be shut down whenever the other is to be used.

Energy costs of startup, idling, and operating must be considered before shutting down a gin during periods of nonginning. A 1,500-hp gin operating at an electric rate of $0.083/kwh has an initial startup cost of about $0.29 and an idling cost of about $1.03/min (based on the gin using 1,000 hp during idling). If the startup time was 2 min and the gin was running at full idle during this period, the total startup cost would be about $2.35. However, the gin does not run at full idle during startup, so the actual startup cost is less than $2.35. Operating power for the gin costs about $1.29/min. When all of these costs are considered, a general rule of thumb is that the gin should be shut down only if nonginning time will exceed 5 min.

Electrical Energy Conservation

The amount of electrical energy used can be reduced in the following ways:

Make good management decisions. This is the most important energy conservation tool available to the ginner, since simple decisions can dramatically influence energy usage.

Improve efficiency. Gins usually operate at about 85-percent efficiency. This means that, on the average, cotton is being ginned by all gin stands 85 percent of the time the motors are running. Much of the inefficiency is due to idle running, which includes gin startup and dryer warmup. However, some of the time is wasted during extended idling periods while adjustments or repairs are made to equipment or while chokages are relieved. Operational failures that require more than 5 min to remedy necessitate partial or complete gin shutdown. The 5-min period may be extended if a substantial warmup time is required for the dryers. Partial shutdowns may also be used. Many ginners are unaware that about 90 percent of full-load energy is used even when cotton is not being ginned.

Observed gin efficiencies range from 72–92 percent, with the more efficient gins having lower energy costs per bale. High-capacity gins with split-stream overhead machinery are normally able to supply sufficient cotton to all the gin stands to maintain full output. Automatic overflow systems recirculate cotton to the distributor and help maintain uniform ginning rates by maintaining a full flow of seed cotton to all gin stands. On suction systems, overflow systems can be automated by installing a level switch that will turn off the automatic feed when the overflow bin is half full. A second method of automating these systems is to connect a series of level switches to signal a microprocessor to change the speed of the automatic feed control or module feeder. The speed is varied to maintain a preset level of seed cotton in the overflow hopper.

Balance the capacity of subsystems. The capacity of each subsystem (such as the unloading, drying, cleaning, ginning, packaging, and waste collection/disposal subsystems) should be balanced so that one subsystem does not bottleneck the entire gin. Careful evaluation of proposed upgrading or modernization programs should be made to ensure that improvements in a subsystem will not be hampered by restrictions in another subsystem. For example, some ginners have replaced gin stands to increase their gin's hourly production capacity, only to discover that the overhead system could not deliver enough cotton to attain the designed ginning rate of the new stands.

Minimize downtime. Preventive maintenance is economically important. Rigid adherence to an approved maintenance schedule will pay dividends in extending machinery life, minimizing breakdowns, lowering maintenance costs, and increasing production efficiency. This schedule should follow the maintenance procedures prescribed by the manufacturer. Log books for machinery should be maintained to provide the ginner with a ready reference for needed maintenance and repair costs. Detection and replacement of a defective bearing during scheduled downtime could save an hour or more of unscheduled downtime during the ginning period.

Have a good safety program. Properly guarded machinery and clean, uncluttered, well-lighted gins play a major role in efficient, safe gin operation. Accidents that cause unnecessary downtime and injuries can be minimized by strict adherence to a good safety program.

Avoid using oversized motors. If the manufacturer recommends a 40-hp motor on a machine, the ginner should not replace the motor with a 50- or 60-hp motor. When motor failure is repeated, the machine, not the motor, is the real problem. The machine malfunction should be corrected, and oversized motors should not be used to overcome the problem. Oversized motors are not as efficient as properly sized ones. Standard motors are designed with a power factor of 0.85 when they are operated at 90 percent of full load. When the load falls below 80 percent, the power factor may fall to less than 0.65. The low power factor means that more of the power is being wasted, and thus the electricity costs to gin a bale of cotton are increased. Replacement motors should be sized so that they will be operated at about 90 percent of their full power load. Amperage readings must be taken both when the gin is operating normally and when there is no cotton in the system, then the higher of the two readings must be used to select the motor.

Control air handling systems. When material is not being moved by centrifugal fans, the fan inlets should be throttled down to reduce the flow of air. This is not the case with vane-axial fans. *Centrifugal fans require minimum horsepower at zero airflow whereas vane-axial fans require maximum horsepower at zero airflow.* The fan speed of unloading fans and automatic overflow fans should be reduced when they are not moving cotton. Throttling devices should be placed at the fan inlet to avoid collapse of the inlet pipe, or the inlet pipe should be adequately reinforced. Ginners should control airflow by reducing fan speeds, rather than by adjusting gate valves, since a gate valve reduces airflow by increasing the pressure a fan must overcome. Only small horsepower reductions can be achieved with gate valves, whereas maximum horsepower savings are achieved by reducing fan speed. Gate valves may be used for equalizing the pressure drop between parallel systems and for changing airflow in systems that require frequent adjustments. Misuse of gate valves will cause much unnecessary expense. Care must be taken to ensure that a vacuum of between 1 and 2 inches of water is maintained at the cleaning machines to minimize dust escaping into the gin and air leaking into the machines. Controlling leakage not only limits the volume of air that fans and cyclone collectors must handle, reducing the needed horsepower and its resultant cost, but also limits escaping emissions for which gins may be held accountable under environmental legislation.

Size fans properly. Since much of the electrical energy consumed in ginning is related to handling materials, special attention should be given to using the proper fan to accomplish the tasks involved. The fan should be operated within the most efficient capacity range and within the speed range recommended by the manufacturer. Fans should not be operated at speeds higher than necessary, and wheel tip speeds should never exceed 18,000 ft/min without approval from the manufacturer.

Moving too much air is expensive and can be minimized by sizing fans properly. The air volume that should be moved can be calculated using two factors: (a) maximum ginning capacity (in bales/hr) and (b) pounds of seed cotton necessary to yield one bale.

Psychrometrics indicates that about 15 ft^3/min of air is needed to dry a pound of seed cotton. To determine the recommended air volume, it is necessary only to multiply the two factors (a and b, defined above) by 15 and to divide the result by the number of minutes in an hour as shown in the equation:

$$\text{Air volume, in ft}^3\text{/min} = \frac{a \times b \times 15}{60} = \frac{a \times b}{4}$$

After the recommended air volume is calculated, check to see whether this volume will maintain the recommended conveying velocities in the system (consult *Section 6–Materials Handling* in this handbook). Each cyclone collector's inlet velocity should be about 3,000 ft/min, and removal of one or more cyclones from service may be necessary to compensate for reduced airflow. If a cyclone is removed, fan speeds can be reduced to compensate for the lower air volume and pressure drop throughout the system.

Power requirements vary as the cube of the fan speed. If the speed of a fan is doubled, the air handling capacity is also doubled; but the resistance pressure is four times as great, and the horsepower consumed is eight times as great. Assume, for example, that a centrifugal fan operating at 1,600 rpm and delivering 4,000 ft^3/min of air against a static pressure of 12 inches of water is using 30 hp. If the speed is increased to 2,200 rpm and all other conditions remain the same, the volume of airflow will be increased to 5,500 ft^3/min, the static pressure (resistance) will be increased to 22.7 inches of water, and the power consumed will increase from the initial 30 hp to 78 hp. The increased fan speed will increase the electricity costs of the fan from $1.86/hr to $4.83/hr. In many instances, purchase of a larger, lower-speed fan can be economically justified.

Since standard radial-type push fans have an overall efficiency of about 50 percent, serious consideration should be given to substituting them with airfoil-type push fans that are about 80-percent efficient. The following data are from a typical gin: capacity, 24 bales/hr; operating time, 24 hr/day and 90 days/season; air, 15 ft^3/min/lb of cotton moved; electricity cost, $0.07/kwh; static pressure in the system, 6 inches; motor efficiency, 85 percent; and seed cotton necessary to yield one bale, 1,500 lb. Replacing radial-type fans with airfoil-type fans in this gin will result in a savings of $130/hp/season. A radial-type gin fan will cost $2,534/season to operate, and an airfoil fan's operation will cost only $1,584—a savings of $950 each season. Since the purchase cost of an airfoil fan is about $1,900, its use will pay back the purchase cost in two seasons and continue to save at least $950 each additional season for the life of the fan. Increases in electrical costs will increase the relative savings even more.

Because airfoil fans are manufactured in many sizes, more information is needed to choose the most economically efficient model. Manufacturers usually have several fans that will meet the operating requirements. For the gin in the previous example, five different fans are suitable; brake horsepowers and efficiencies of these fans range from 16.7 hp and 53 percent for the smallest wheel to 10.5 hp and 85 percent for the largest. Before a decision can be made on which fan to select, an economic evaluation must be performed to determine at what point horsepower savings offset purchase costs. For the typical gin in the previous example, the use of the largest fan instead of the smallest would save $862/season; at a purchase cost of nearly $5,200, the payback period for the largest fan would be 6 yr. Midsize fans operating at 78 percent efficiency use 5.7 hp less than the smallest fans and are priced at about $2,400. At $140/hp/season, the payback period for a midsize fan would be 3 yr.

Replace motors that have become inefficient. The National Electric Motor Association (NEMA) has now standardized motor ratings so that "high efficiency" no longer means anything the manufacturer wants it to mean. To be considered high efficiency, a motor must now have a nameplate efficiency in the range shown in table 8–1.

Each time a motor is rewound it becomes somewhat more costly to operate due to core loss. Recent studies by the Electrical Apparatus Service Association and General Electric indicate that core losses averaged 32 percent during rewind, with some going as high as 400 percent. Motors can be made to run for years, but at ever-increasing cost. Core losses can be measured by some repair shops so that informed decisions can be made about whether to rewind or replace motors. Energy-efficient motors can be stripped and rewound with slightly less core loss than standard motors. Although a motor may run after several rewindings, its efficiency may be so reduced that the ginner may mistakingly replace it with a motor of higher horsepower after making the assumption that more power is needed. Replacement with ever-larger motors can begin an upward cost spiral that is totally unnecessary.

Reduce gin demand. In some cases, load can be managed to reduce demand. Care should be taken to avoid starting up too many machines within a short period of time. If several machines are started simultaneously or if a

Table 8–1.
Full-load efficiencies of three-phase four-pole energy-efficient motors[1]

Horsepower	Nominal efficiency range (percent)	Average nominal efficiency (percent)
1	80–84	83.0
1.5	81–84	83.0
2	81–84	83.0
3	83.5–88.5	86.0
5	85–88.5	87.0
7.5	86–90.5	88.0
10	87.5–90.5	89.0
15	89.5–91.5	90.0
20	90.0–93.0	90.5
25	91.0–93.0	91.5
30	91.0–93.0	92.0
40	91.5–93.0	92.5
50	91.5–94.0	93.0
60	91.0–94.0	93.0
75	92.0–95.0	93.5
100	93.0–95.0	94.0
125	93.0–95.0	94.0
150	93.0–96.0	94.5
200	94.0–95.5	94.5

[1]Based on NEMA standards.

second motor is started before the amperage of the first recently started motor reduces to operating load, demand will probably increase for that monthly billing cycle. Care should also be taken to ensure that high-horsepower machines, such as the universal density press, are used properly. For instance, if a large bale (575 lb) is inadvertently ginned and the press is unable to attain its desired fixed platen separation (high cutoff), the press motors may continue to use in excess of 100 percent of their rated power until the proper platen separation is reached or until the motors are stopped. The net effect of the malfunction will be a higher demand charge for that month.

Load shedding involves control of the operating period of machinery and is used in many industries. One example of load shedding in a gin would be to decrease the speed of the unloading fan when the power requirement of the bale press is high as the ram nears the end of its compression stroke. For a 20-bale-per-hour gin that cycles the bale press once every 3 min for a period of about 30 sec, the speed of the unloading fan could be throttled for the last 5–10 sec of ram travel. This process would substantially decrease instantaneous demand.

Keep good records. The importance of accurate operating records cannot be overstated. An accurate log of individual pieces of equipment can help greatly in evaluating the efficiency of systems so that major expenditures can be predicted. Installing a time clock on each gin stand and logging the number of hours of operation between routine maintenance functions can indicate when to schedule major overhauls during the off-season so that downtime will be minimized. Even minor preventive maintenance measures should be scheduled so that they are least disruptive.

An operating log can contain information that convinces a grower to improve harvesting practices to raise bale grades. Reductions in both chokages and processing costs make grower cooperation in harvesting invaluable.

Stay informed about new technology. Several new technological developments can be used to reduce energy consumption of electric motors. The three most promising are: (1) high-efficiency motors, (2) capacitors, and (3) motor-energy-loss controllers. In a total energy management program, each may have its place. The biggest drawback to obtaining this equipment is the initial cost, which is difficult to recover quickly because of the limited number of operating hours per year.

High-efficiency motors should run at their rated design loads for the greater part of the duty cycle. These motors are designed to minimize internal losses and to maximize efficiency under full-load conditions. However, when these motors are overpowered (that is, they are too large for the load they are handling), their energy efficiency is poor. When handling their designed load, high-efficiency motors typically offer a 2–10 percent increase in efficiency. The increased efficiency results in a 2–10 percent decrease in operating costs. These motors require a long payback period (up to 4,000 hr), so it may not be economical to replace those that are still working. However, when wornout motors are replaced, strong consideration should be given to using high-efficiency motors.

Capacitors can be used to raise the power factor of motors and thus reduce their power consumption. Typically, payback on capacitor investments will be reached in 3,000 hr or less, depending on the existing power factor of the gin.

When motors operate at reduced loads, their efficiency falls dramatically. This drop in efficiency can be reduced by a motor-energy-loss controller (MELC)—a device that monitors the motor load and adjusts the voltage of the motor accordingly. When a MELC is used, power savings of 30 percent are not uncommon during light loads. Payback occurs in 4,000 hr or less. The most appropriate application for a MELC in gins is at a bale press motor that is operated continuously; in this location electricity savings of 50 percent or more are possible. In universal density presses currently in use, MELC's could reduce the electricity consumption about 1.5 kwh/bale or about $0.12/bale at a cost of $0.083/kwh. MELC's can be justified in new press installations where the reduced voltage starter and the MELC can be incorporated into the same unit.

The addition of MELC's to existing press motors requires evaluation on a case-by-case basis.

Fuel Energy Conservation

Management of cotton drying systems to minimize fuel usage has not been strongly considered in the past because of relatively low fuel costs. Recent price increases of fuel and the prospects for additional increases have focused attention on the conservation of dryer fuel. A ginner can do the following to improve dryer efficiency:

Avoid unnecessary drying. Use only the amount of drying required to lower the fiber moisture content to 6–8 percent. During periods of low relative humidity, cotton often arrives at the gin with a fiber moisture content within the desired range. When this occurs, the dryers should be bypassed. Some gins are not equipped with bypass valves, and in those cases the burners can be turned off. When a bypass valve is used, one of the centrifugal fans can be turned off, thereby producing a savings in electricity as well. Effective moisture and temperature sensors and controllers are essential to obtain proper dryer control so that unnecessary drying is avoided. Some ginners have a tendency to apply the same drying temperature to all cotton regardless of its moisture content. Accurate sensors to measure the moisture before and after drying and to control the dryers are absolutely necessary. New technology that uses infrared sensors may be used.

Use properly designed dryers. Burners should be positioned close to the dryer to avoid unnecessary loss of heat between the burner and the dryer. Dryers should provide adequate retention time to allow sufficient drying. Burner capacity must be sized with the desired cotton flowrate, air flowrate, and moisture removal in mind. Improperly designed drying systems waste energy and cause inadequate or excessive drying.

Adjust the burner flame. The air/fuel mixture should be adjusted until the flame at the end of the burner burns bright blue. A yellow flame indicates incomplete combustion, which wastes fuel. Another frequent problem is that of long flames extending far enough to set fire to the cotton. Such flames can often be controlled by installing an air-diffusing flame holder that has been properly designed for the specific burner.

Maintain proper burner control. Many gins have burners with antiquated and unsafe control systems. For protection of both people and equipment, burners should be equipped with control systems that meet all current construction and safety codes, and obsolete on/off temperature controls should be discarded. A maintenance program must be rigidly followed to keep the controls in perfect condition. Not only does a modern control system yield obvious safety advantages, it also gives the drying system much more rapid and accurate response capability. If the system is able to change temperatures rapidly in very small increments, fuel can be conserved by using only what is required at a given moment.

Among the control system components needed to achieve uniform drying with maximum fuel savings are double safety shutoff valves between the gas supply and burner, an automatic shutoff mechanism for flame failure, automatic ignition, an automatic purging device, a modulating valve that will hold the temperature within 10 °F of the set point, a temperature-limiting device at the mixpoint of cotton and heated air, and moisture sensors before and after drying.

A limiting thermocouple must be installed within 10 ft of the cotton-air mixpoint to prevent temperatures from exceeding 350 °F. The temperature-sensing device for the controls should be installed at the first turn on the top shelf of a tower dryer.

Insulate the dryer. Research has indicated that about 30 percent of the heat lost in drying systems by radiation and convection can be retained by covering the dryer and hot-air pipes with thermal insulation (Griffin 1979, Childers 1978b). Insulation is relatively inexpensive and can be installed by gin personnel. Money spent on dryer fuel can be reduced about 25 percent by proper insulation. If dryer fuel costs $1.00/bale, then insulating could result in a savings of $0.25/bale. Insulating a typical two-stage drying system will cost $2,500–$4,500 for material and labor, depending on pipe length, number of elbows, labor cost, etc. The cost should be paid back after 8,000–16,000 bales are ginned. Insulation can be rigid or flexible but must be approved for temperatures above 1,000 °F by Underwriters' Laboratory. All hot-air ducts between the burner and the dryer should be insulated. The most economic choice of insulation at this time is a 2-inch-thick rigid fiberglass board available in sections of any size. The bonding agent in this insulation will withstand temperatures up to 850 °F. In cases where additional insulating value is needed, the product can be purchased in 2-1/2 -inch and 3-inch thicknesses.

When the thermocouples are placed as recommended above, there is no economic advantage in insulating the tower, nor is there any reason to insulate the duct after the dryer because the drying material rapidly cools the air. An exception exists in systems in which the drying air is reused, making it economically sound to insulate as much as possible.

Use heat recovery devices. Warm exhaust air is normally emitted into the atmosphere. Research at the Southwestern Cotton Ginning Research Laboratory (Leonard et al. 1979) suggests that the warm exhaust air from the first stage of drying can be fed into the intake of the second stage of drying, but air-cleaning devices should be used to remove leaf trash, lint fly, dust, etc., from the air to avoid reentrainment of the debris with the cotton. This process of reusing the air can result in fuel savings of 20 percent. Just relocating the air intake for the burners near the air exhaust (on the roof of the building) can result in fuel savings of as much as 15 percent.

Warm-air exhaust lines can act as heat exchangers. A heat exchanger can be as simple as two concentric pipes in which warm air is exhausted through the inner pipe and fresh air is passed in the opposite direction through the outer pipe (Childers 1978a). The fresh intake air does not make physical contact with the exhaust air but is warmed by it. A fuel savings of 3–10 percent is possible from this warming effect.

Consider alternative energy sources. When incinerated, gin waste has a heat value of 7,000 Btu/lb. A 30-percent recovery of this heat is enough to provide most of the heat required for drying cotton. Sustained incineration of gin waste, however, is currently the limiting factor. Several current research projects are underway to develop new technology for the use of gin waste. Since the technology is not adequately developed, no further discussion is provided in this book.

Energy Conservation Techniques

Energy conservation in the future is a must. Several energy conservation techniques are outlined below.

1. Use good management practices.
2. Maintain high gin efficiency.
3. Balance subsystems (that is, each phase of the gin process, such as gin stands, lint cleaners, bale presses, should have the same capacity).
4. Minimize downtime.
5. Have a good safety program.
6. Avoid using oversized motors.
7. Throttle down air-handling systems.
8. Use properly sized fans.
9. Replace inefficient motors that have been rewound too often.
10. Control electrical demand.

11. Use high-efficiency motors.
12. Maintain good records.
13. Use capacitors to increase the power factor of motors.
14. Use MELC's to maximize the power factor of motors.
15. Avoid unnecessary drying of cotton that arrives at the gin at 8 percent moisture content or lower.
16. Use dryer controls to modulate fuel use in response to cotton moisture.
17. Use properly designed dryers.
18. Insulate hot air lines and dryers.
19. Use heat recovery devices.
20. Use an effective preventive maintenance program.

Awareness of the capabilities and constraints of a gin and its operating personnel and the subsequent use of good management will result in lower energy costs during ginning.

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SECTION 9—
GINNING
RECOMMEN-
DATIONS

Effects of Gin Machinery on Cotton Quality

William D. Mayfield, W.S. Anthony, R.V. Baker, and S.E. Hughs

Cotton quality is affected by every production step, including selecting the variety, harvesting, and ginning. Certain quality characteristics are highly influenced by genetics, while others are determined mainly by environmental conditions or by harvesting and ginning practices. Problems during any step of production or processing can cause irreversible damage to fiber quality and reduce profits for the producer as well as the textile manufacturer.

Fiber quality is highest the day a cotton boll opens. Weathering, mechanical harvesting, handling, ginning, and manufacturing can diminish the natural quality.

In addition to its principal function of separating lint from seed, the modern cotton gin is equipped to modify the moisture content and remove a large percentage of the foreign matter that would significantly reduce cotton value. Ginners must have a twofold objective: (1) to produce lint with a trash content satisfactory to the growers' market and (2) to gin the cotton with minimum reduction in fiber spinning quality so that it will meet the demands of its users—the spinner and the consumer.

There are many factors that indicate the overall quality of cotton fiber. The most important ones include strength, fiber length, short fiber content (fibers shorter than one-half inch), length uniformity, maturity, fineness, trash content, color, seedcoat fragment and nep content, and stickiness. The market generally recognizes these factors even though not all are measured on each bale.

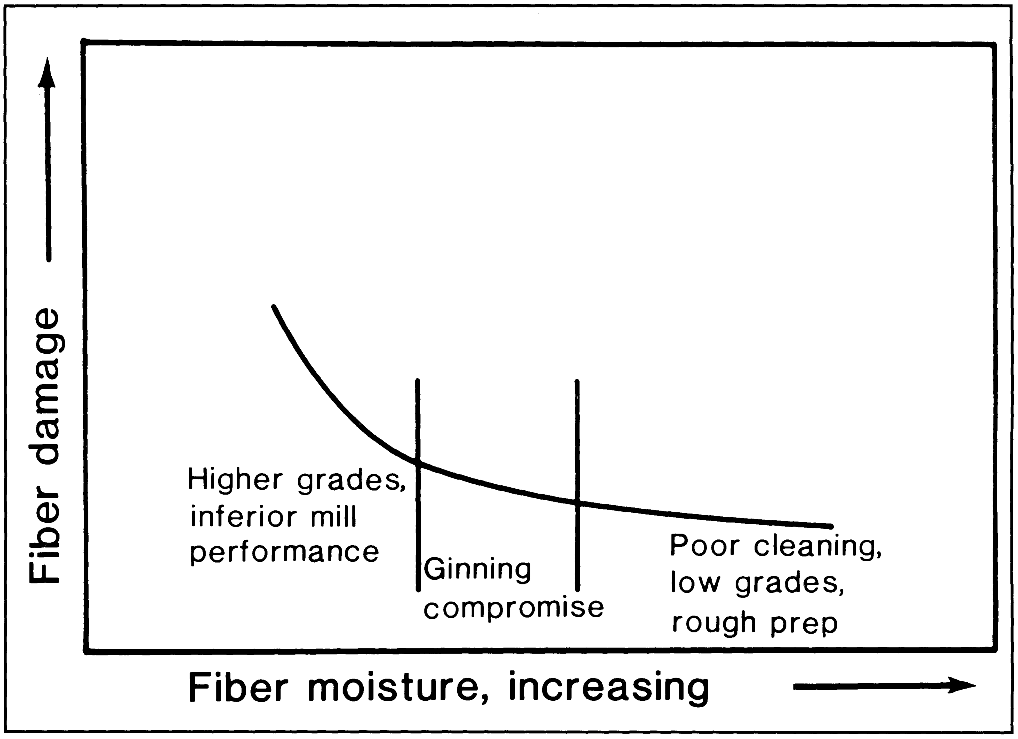
The ginning process can significantly affect fiber length, uniformity, and the content of seedcoat fragments, trash, short fibers, and neps. The two ginning practices that have the most impact on quality are (1) the regulation of fiber moisture during ginning and cleaning and (2) the degree of gin cleaning used.

Moisture Content

The recommended lint moisture range for ginning is 6-7 percent. Gin cleaners remove more trash at low moisture but not without more fiber damage. Higher fiber moisture preserves fiber length but results in ginning problems and poor cleaning (fig. 9–1).

The average fiber strength for upland cottons at 7 percent moisture is about 1.8 times the fiber-seed separation force (Anthony et al. 1988). Lowering fiber moisture decreases individual fiber strength, causing more fibers to break during ginning. For each 1 percent reduction in fiber moisture content below 5 percent, the number of short fibers are increased by almost 1 percent. The effects of ginning cotton below 5 percent moisture are decreased

Figure 9–1. The acceptable moisture content of cotton being ginned is a compromise between grade level and fiber damage.



yarn strength and yarn appearance and increased short fibers in the card sliver. Also, overheating may cause increased fiber breakage from the mechanical action of cleaning in the gin and textile mill.

If drying is increased to improve trash removal, yarn quality is reduced. Although yarn appearance improves with drying up to a point because of increased foreign-matter removal, the effect of increased short-fiber content outweighs the benefits of foreign-matter removal.

Gin Cleaning

Choosing the degree of gin cleaning is a compromise between fiber trash content and fiber quality (fig. 9–2). Lint cleaners are much more effective in reducing the lint trash content than seed cotton cleaners, but lint cleaners can also damage fiber quality and reduce bale weight (turnout) by discarding some good fiber with the waste.

Cleaning does little to change the true color of the fiber, but combing the fibers and removing trash changes the perceived color. Lint cleaning can sometimes blend fiber so that fewer bales are classified as spotted or light spotted. Ginning does not affect fineness and maturity.

Each mechanical or pneumatic device used during cleaning and ginning increases the nep content, but lint cleaners have the most pronounced

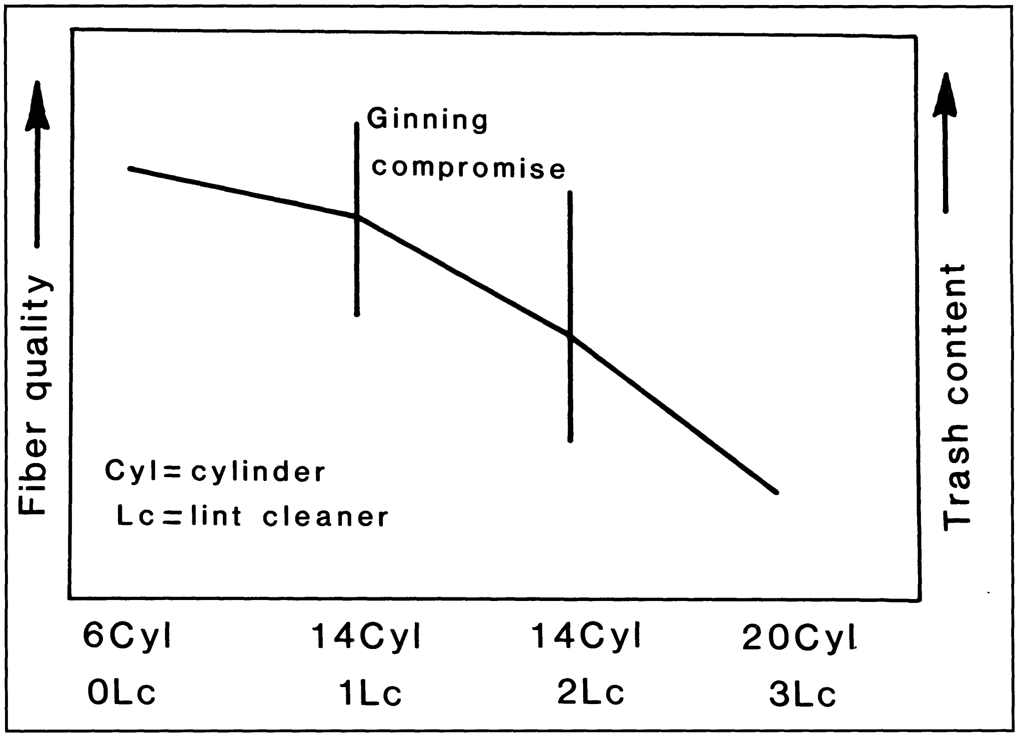


Figure 9–2. Cleaning at the gin is a compromise between fiber quality and trash removal.

influence (Mangialardi 1985). The number of seedcoat fragments in ginned lint is affected by the seed condition and ginning action. Lint cleaners decrease the size but not the number of fragments (Anthony et al. 1988). Yarn strength, yarn appearance, and spinning-end breakage are three important spinning quality elements. All are affected by length uniformity and, therefore, by the proportion of short or broken fibers. These three elements are usually preserved best when cotton is ginned with minimum drying and cleaning machinery.

Seed cotton cylinder cleaners decrease the lint trash content, but they slightly decrease the yarn strength. The yarn appearance is improved by cylinder cleaners, but using more than 14 cylinders in a gin can cause quality problems.

Balancing Fiber Quality and Cleaning

Whether it is done in a gin or in a textile mill, cleaning generally lowers most of the important fiber quality characteristics other than the trash content and reduces the amount of usable fiber (turnout). Ginners must compromise between trash removal and fiber damage when choosing their cleaning machinery. For machine-picked cotton, ginners should use 12–14 cylinders of seed cotton cleaning along with a stick machine and one or two lint cleaners, depending on seed cotton trash content and color potential. For stripped cotton, a second stick machine and an air line cleaner or cleaning separator should be included. To deliver the absolute highest quality products, growers and ginners must take care during production, harvesting, ginning, and textile manufacturing to avoid practices that may diminish fiber quality.

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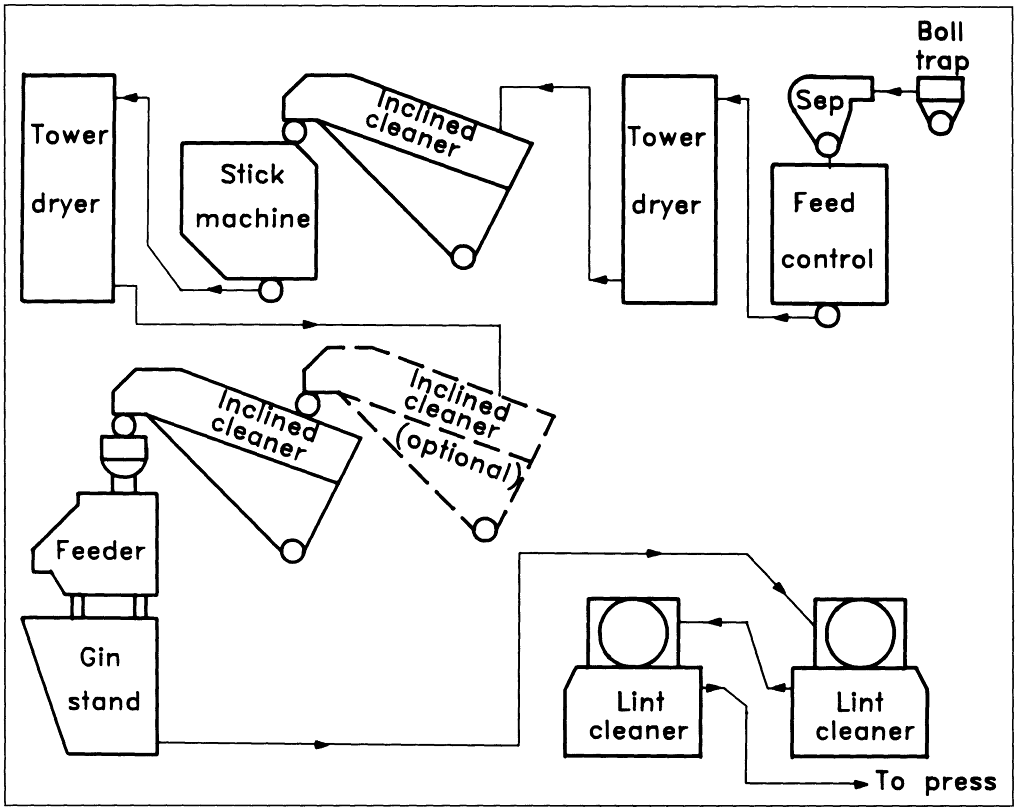
Ginning Recommendations for Processing Machine-Picked Cotton

W.S. Anthony, S.E. Hughs, and William D. Mayfield

Recommendations for the sequence and amount of gin machinery to dry and clean spindle-harvested cotton are based on research by the Cotton Ginning Laboratories of the Agricultural Research Service and by cooperating organizations. These recommendations were designed to achieve satisfactory bale value and to preserve the inherent quality of cotton. They have generally been followed and thus confirmed in the U.S. cotton industry for several decades. The recommendations consider marketing system premiums and discounts as well as the cleaning efficiency and fiber damage resulting from various gin machines. Some variation from these recommendations is necessary for special harvesting conditions. The recommended sequence and amount of machinery for processing machine-picked cotton are shown in figure 9–3. Both cylinder cleaners in the sequence should have five to seven cylinders. The optional inclined cleaner is recommended for trashy or difficult-to-clean cottons.

Figure 9–3 shows the maximum amount of machinery that should be needed. Foreign-matter levels in seed cotton usually range from 5 to 10 percent before gin processing, but levels of 12–14 percent do occur. The foreign matter level dictates the cleaning level needed. Obviously, any machinery that is not necessary for a particular lot of cotton should be bypassed. Dryers, seed cotton cleaners and extractors, and lint cleaners should be provided with bypasses to allow the cotton to skip these machines when extra-clean, dry cotton is brought to the gin. Extensive use of module storage during the last decade has increased the amount of relatively dry cotton that enters the ginning system. In addition, special market conditions also influence the amount of equipment needed. Machine-picked upland cotton varieties from across the Cotton Belt have similar cleaning characteristics. Some varieties, typically those that have large quantities of trichomes (hair)

Figure 9–3. Recommended gin machinery for machine-picked cotton



on plant surfaces, are difficult to clean. One additional stage of cleaning may be required for hairy-leaf cottons.

Dryers should be adjusted to supply the gin stand with lint having a moisture content of 6–7 percent. Research has shown that cotton at this moisture level is more able to withstand the stresses of ginning without breaking.

The quality of ginned lint is directly related to the quality of the cotton before ginning. High grades will result from cotton that comes from clean fields harvested by properly adjusted machines in good condition. Lower grades will result from cotton that comes from grassy, weedy fields in which poor harvesting practices are used.

When gin machinery is used in the recommended sequence, 75–85 percent of the foreign matter is usually removed from cotton. Unfortunately, this machinery also removes small quantities of good quality cotton in the process of removing foreign matter, so the quantity of marketable cotton is reduced during cleaning. Cleaning cotton is therefore a compromise between foreign matter level and fiber loss and damage.

The grade of the cotton is improved during cleaning as foreign matter is removed and the fiber is combed and blended. Judicious use of the gin machinery combinations discussed here should yield good returns to the producer and provide cotton fiber of acceptable quality to spinning mills.

Ginning Recommendations for Processing Machine-Stripped Cotton

R.V. Baker

Because machine-stripped cotton contains 6–10 times as much foreign matter as machine-picked cotton, ginning systems in stripper areas have to be more elaborate than those in picker areas. Additional extraction equipment is required to handle large amounts of burs and sticks. Unless removed, burs and sticks will seriously lower gin stand performance and result in unacceptably high trash contents for cottonseed and ginned lint. Provisions also have to be made for removing green bolls and sand from stripped cotton early in the seed cotton cleaning process.

Even though the cleaning requirements of stripped cottons vary from year to year and to some extent from variety to variety, the following array of gin machinery is near optimum for most conditions and is summarized in figure 9–4:

1. Green-boll trap (should be located in the conveying line or there should be a green-boll separator at the air pickup on the module feeder belt)
2. Air line cleaner or combination air line cleaner/separator
3. Feed control
4. Tower dryer or equivalent
5. Cylinder cleaner (five to seven cylinders)
6. Combination bur and stick (CBS) machine
7. Tower dryer or equivalent
8. Cylinder cleaner (five to seven cylinders)
9. Stick machine
10. Extractor-feeder
11. Saw gin stand
12. Saw-cylinder lint cleaner
13. Saw-cylinder lint cleaner
14. Press

The machinery recommendations shown schematically in figure 9–4 are general in that they are appropriate for most gins handling stripper-harvested cotton at typical conditions. Under such conditions, the recommended machinery arrangement will produce satisfactory lint grades and near-maximum bale values for most cottons. However, modification of the recommendations may be necessary in some production areas to meet special needs or unusual growing conditions. Cotton containing excessive amounts of foreign matter, particularly stick material, or hard-to-clean varieties of cotton may require more cleaning than can be obtained with the basic machinery arrangement. An extra stick machine or extra cylinder cleaner in the seed cotton cleaning sequence will usually overcome special problems.

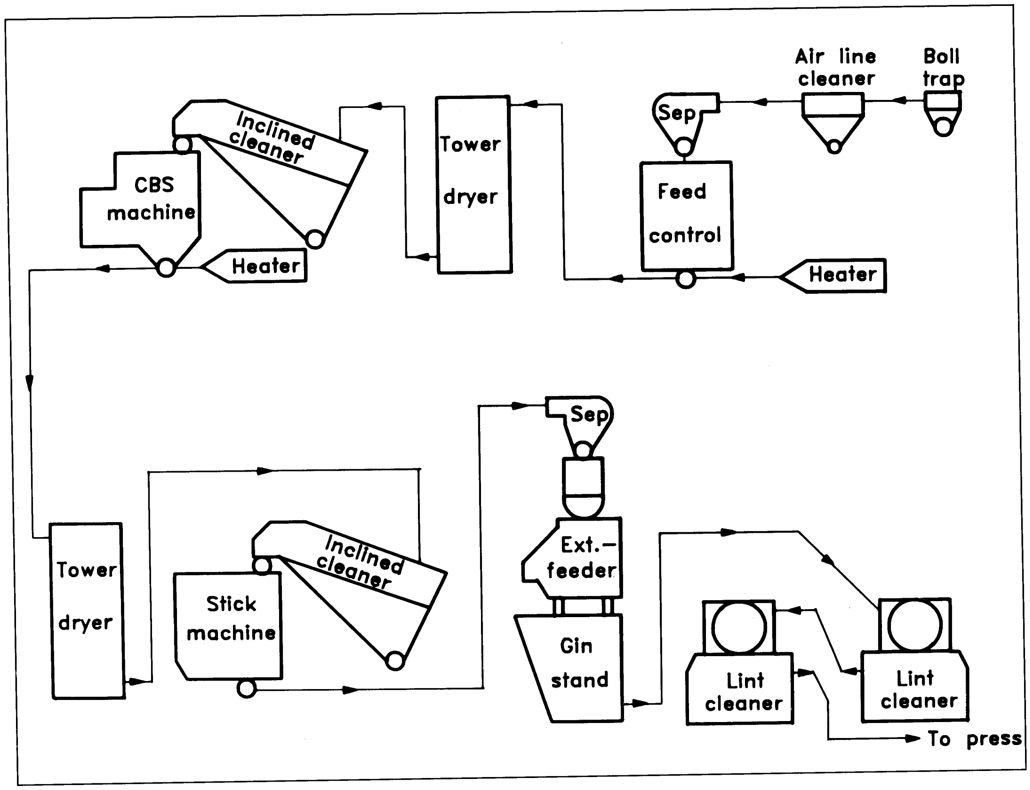


Figure 9–4. Recommended gin machinery for machine-stripped cotton

On the other hand, very clean cotton can often be satisfactorily cleaned with less machinery. For this reason, seed cotton extractors and lint cleaners should be provided with bypasses to allow for selection of less cleaning machinery. Generally, ginners should select the minimum amount of machinery required to maximize bale value for the producer. In this way they can minimize ginning costs and at the same time do a better job of preserving the inherent qualities of the cotton fiber.

SECTION 10— ROLLER GINNING

Marvis N. Gillum, D.W. Van Doorn, B.M. Norman, and Charles Owen

Roller-type gins provided the first mechanically aided means of separating lint from seed (Bennett 1960). The Churka gin, which has an unknown origin, consisted of two hard rollers that ran together at the same surface speed, pinching the fiber from the seed and producing about 2 lb of lint/day. During the 1700's, a series of developments using the roller principle followed, but ginning rates remained low. The next major development in the ginning industry occurred in 1794, when Eli Whitney invented a gin that removed fiber from the seed by means of spikes on a cylinder. In 1796 Henry Ogden Holmes invented a gin having saws and ribs; this gin replaced Whitney's gin and made ginning a continuous-flow process rather than a batch process. Whitney's and Ogden's gins, however, were not used on extra-long-staple (ELS) cottons; Churka gins continued to be used on ELS cottons through the early 1800's.

In 1840, Fones McCarthy invented a more efficient roller gin that consisted of a leather ginning roller, a stationary knife held tightly against the roller, and a reciprocating knife that pulled the seed from the lint as the lint was held by the roller and stationary knife. Although the McCarthy gin was a major improvement over the Churka-type gin, machine vibration due to the reciprocating knife along with attendant gin stand maintenance problems prohibited high ginning rates.

In the late 1950's and early 1960's, a rotary-knife roller gin was developed by the U.S. Department of Agriculture, Agricultural Research Service's Southwestern Cotton Ginning Research Laboratory, gin manufacturers, and private ginneries. This gin is currently the only roller-type gin used in the United States. The roller and stationary knife of this gin are similar to those of the McCarthy gin, but a rotary knife is used instead of a reciprocating knife. The rotary knife vibrates less and is more efficient than the reciprocating knife, which wasted time during each backstroke. The rotary-knife gin allows faster ginning rates than the McCarthy gin allowed. During the 1993–94 season, there were 38 roller-ginning plants in the United States—16 in Arizona, 7 in Texas, 12 in California, and 3 in New Mexico (Supima Association of America 1993).

Since only 6 percent (Supima Association of America 1989, U.S. Department of Agriculture 1989) of the world cotton production is ELS cotton, a specialty market exists for this type of cotton, and textile mills pay a premium for it. Pima cotton, the only ELS cotton grown in the United States, successfully competes with other ELS cottons worldwide. Pima cotton belongs to the species *Gossypium barbadense* (Niles and Feaster 1984). The early cultivars of *G. barbadense* were known as American-Egyptian cotton; the germplasm was reintroduced from Egypt. Production of pima cotton in the Southwestern United States began in 1908 with the 'Yuma' variety. 'Pima S–1' was introduced in 1951 and was developed from crosses of 'Sea Island', 'Pima', 'Tanguis', and 'Stoneville', the latter being an upland (species *G. hirsutum*) variety. Compared with previously developed pima cottons, 'Pima S–1' had larger bolls, a higher lint percentage, and small but highly productive plants. The 'Pima S' variety has continually improved, with 'Pima S–7' being the latest release. Pima cotton fiber is long (46/32-inch staple length), strong (35 g/tex strength), fine (3.8 micronaire), and used in the finer apparels.

Pima cotton is roller ginned to preserve fiber quality. Even though the roller-ginning rate is about one-fifth the saw-ginning rate, interest has recently risen in roller ginning upland cotton to reduce the amount of raw-fiber neps and fiber breakage that occur in saw ginning (Hughs and Lalor 1989). There are two disadvantages to consider before roller ginning upland cotton. First, because of the greater strength of attachment of the fiber to the seed in upland cotton (Chapman 1969), the roller-ginning rate of upland cotton is about 30 percent lower than that of pima cotton, causing higher ginning costs. Secondly, roller ginning removes some of the short fibers (linters) from the upland seed and therefore may increase the short-fiber content of the lint.

Upland cotton that has been roller ginned is sold directly to the spinning mill on a contract basis and is for special use. The increased ginning cost and absence of an established market make roller ginning of upland cotton very risky unless a purchaser has agreed (in a contract) to buy the ginned cotton before ginning takes place.

Seed Cotton Harvesting and Storing

Being such a valuable product, pima cotton must be harvested and stored with the utmost care. Fields having a lot of litter, weeds, green leaves, or immature bolls or having a high moisture content should not be harvested until conditions are improved (Calhoun 1988). Cotton that contains excess green leaves or moisture (12 percent or more) should not be harvested unless the cotton can be ginned immediately. Harvesting under unfavorable conditions contributes to spindle twist and reduced fiber grade. Picking machines must be in the best condition possible; the water system, spindles, and cabinet and picker-bar alignment must be properly set to avoid spindle twist. Spindle twists do not gin properly (they hang up on the stationary knife) and cause reduced ginning rates and possible damage to the ginning roller. Also, spindle twists usually remain with the lint, reducing the value of the producer's crop and causing problems at the spinning mill.

Modules allow long-term storage of cotton. The moisture content of cotton before and during storage is critical; excess moisture causes stored cotton to overheat, resulting in lint discoloration, lower seed germination, and possibly spontaneous combustion (Calhoun 1988). Seed cotton above 12 percent moisture content should not be stored (Willcutt et al. 1989). Also, the internal temperature of newly built modules should be monitored for the first 5–7 days of cotton storage; modules that experience a 20 °F rise or are above 120 °F should be ginned immediately to avoid the possibility of major loss.

Seed Cotton Conditioning

Seed cotton conditioning equipment in roller gins is the same type used in saw gins. Cleaning equipment includes cylinder cleaners, stick machines, and revolving screen (impact) cleaners. Hughs and Gillum (1991) reported that the total number of seed cotton cleaners (not including the feeder) used in roller-ginning plants ranged from three to eight, with four or five cleaners being most commonly used. Ginners must avoid using too many machines when conditioning pima seed cotton for ginning; the extra cleaning stages may make the locks string out and become twisted.

Tower dryers and hot-air cylinder cleaners are commonly used for seed cotton drying. Optimum fiber moisture content for roller ginning is 5–6 percent (Leonard and Gillum 1974). Drying fiber lower than 4 percent may result in static-electricity problems and fiber breakage. Hughs and Gillum (1991) reported that all United States roller-ginning plants have at least one stage of drying, 98 percent have at least two drying stages, and 59 percent have three drying stages. Also, 27 percent having drying-system setpoint temperatures in excess of 225 °F. Set point temperature is ideally measured shortly after the mixpoint (where seed cotton and drying air first converge). Mixpoint temperature should be monitored or automatically limited to no more than 350 °F and preferably should be less than 300 °F because high drying temperatures damage fiber and waste energy.

Rotary-Knife Roller Gin Components

Cross sections of three rotary-knife roller gin stands and seed cotton feeders are shown in figures 10–1 through 10–3. Proper feeder operation contributes to the efficiency of the gin stand; feeder output must be uniform and steady. Ginning rate and carryover (unginned seed cotton that accompanies the seed) increase with feed rate. Optimum feed rate is difficult to obtain because the condition of the seed cotton varies. Gillum (1983) and Gillum and Armijo (1991) reported that using rotary-knife power as the input to a closed-loop computerized controller to control feed rate increases ginning rate.

Figure 10–1. Cross section of seed cotton feeder and rotary-knife roller gin stand. *1*, Feed rollers, 0–13 rpm; *2*, Spray system; *3*, Rotary knife; *4*, Stationary-knife holder; *5*, Countershaft, 361 rpm; *6*, Ginning roller; *7*, Preparation cylinders, 745 rpm; *8*, Trash conveyor; *9*, Spiked cleaning cylinders, 745 rpm (courtesy of Consolidated Cotton Gin Co., Inc.).

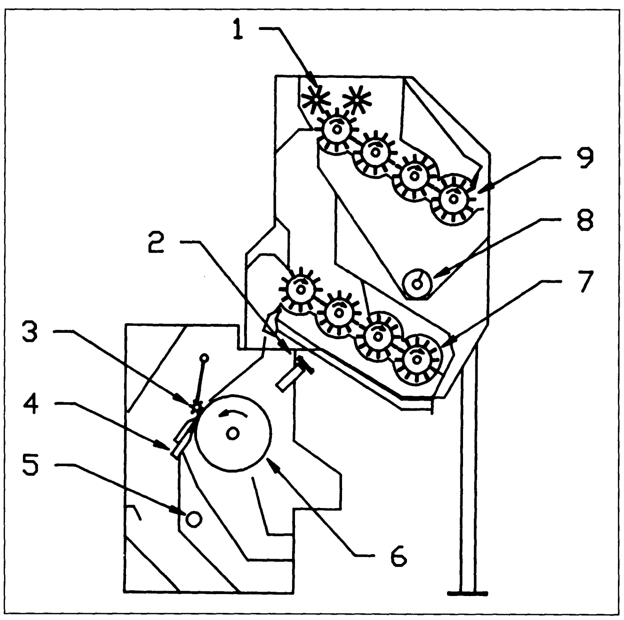


Figure 10–2. Cross section of seed cotton feeder and rotary-knife roller gin stand. *1*, Feed rollers, 0–10 rpm; *2*, Dust hood; *3*, Main saw, 316 rpm; *4*, Rotary knife; *5*, Stationary knife; *6*, Knife bar; *7*, Jack shaft, 316 rpm; *8*, Ginning roller; *9*, Doffing brush, 1,308 rpm; *10*, Reclaimer saw, 351 rpm; *11*, Spiked cylinder, 530 rpm (courtesy of Continental Eagle Corporation).

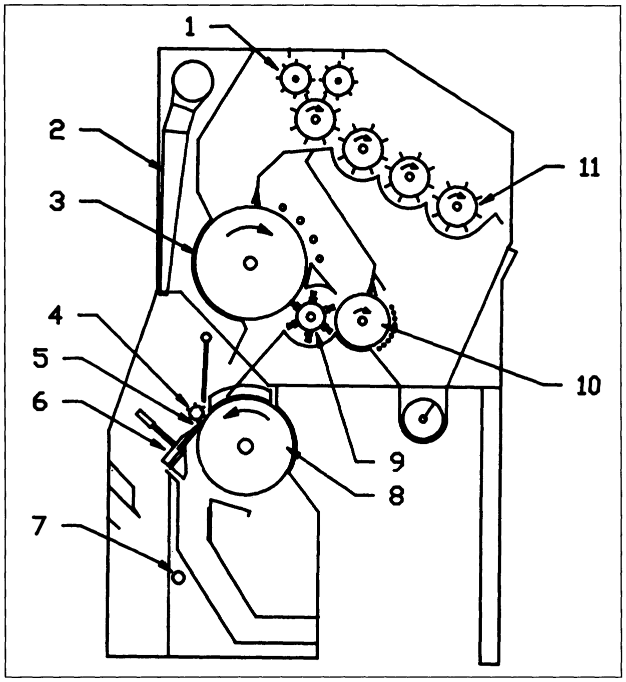
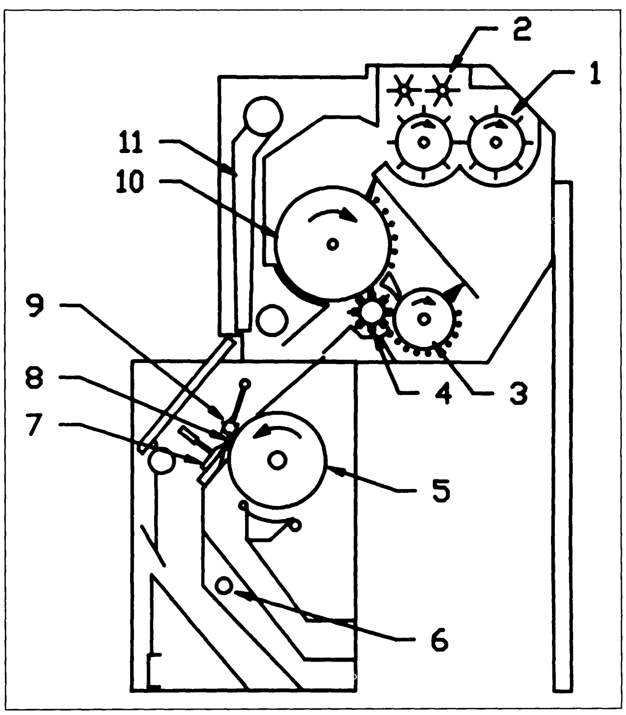


Figure 10–3. Cross section of seed cotton feeder and rotary-knife roller gin stand. *1*, Spiked cleaning cylinders, 542 rpm; *2*, Feed rollers, 0–12 rpm; *3*, Reclaimer saw cylinder, 306 rpm; *4*, Brush doffing cylinder, 1,354 rpm; *5*, Packing roll; *6*, Jack shaft, 435 rpm; *7*, Knife holder; *8*, Stationary knife; *9*, Rotary knife; *10*, Main saw cylinder, 345 rpm; *11*, Dust hood (courtesy of Lummus Corporation).



The main components of a rotary-knife roller gin stand include the stationary knife, rotary knife, and ginning roller (packing roll). The views of these components are shown in figures 10–4 through 10–6 and dimensions are given in table 10–1. The stationary knife must be hard and abrasion resistant—it may chip if it is too brittle. Also, the stationary knife must be ground to the proper size and shape; grinding to less than A_{min} (see fig. 10–4 and table 10–1) or to a wrong angle makes gin stand adjustment very difficult.

Figure 10–4. View of a stationary knife of a roller gin stand (see table 10–1 for dimensions)

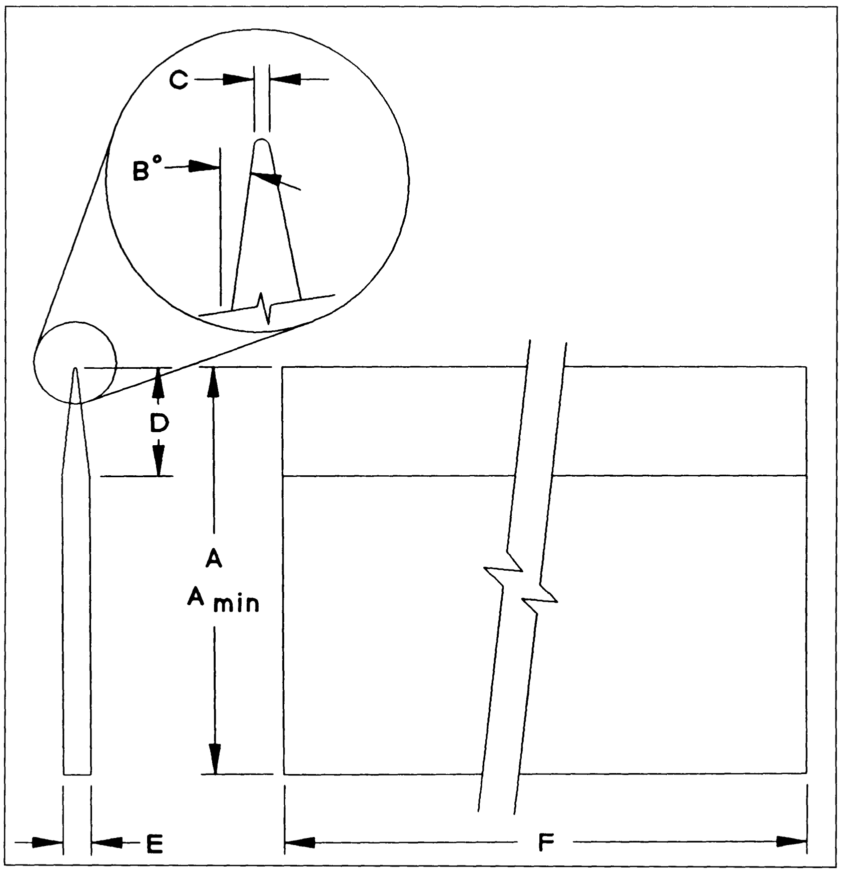


Figure 10–5. View of a rotary knife of a roller gin stand (see table 10–1 for dimensions). *Dia.*, diameter.

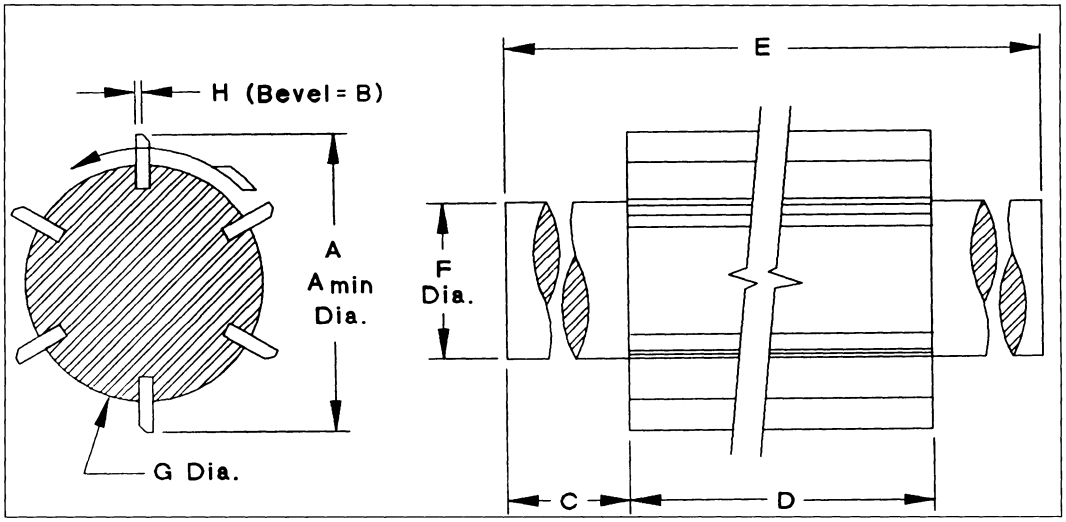


Figure 10–6. Sectional view of a roller in a roller gin stand (see table 10–1 for dimensions). *O.D.*, Outside diameter.

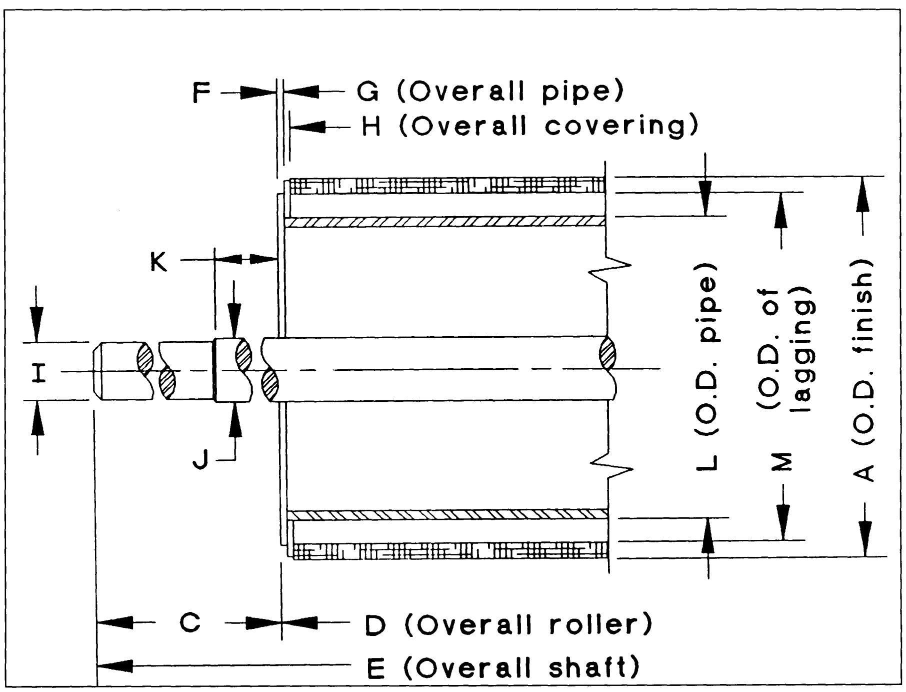


Table 10–1.
Component dimensions of the stationary knife (fig. 10–4), rotary knife (fig. 10–5), and ginning roller (fig. 10–6) in a rotary-knife roller gin stand[1]

Manufacturer and model	A	A_{min}	B (degrees)	C	D	E	F	G	H	I	J	K	L	M
Consolidated Gin Co.														
Stationary knife	3.75	3.50	6.24	0.031	1.00	0.250	40.25	-	-	-	-	-	-	-
Rotary knife	2.75	2.625	45.00	4.00	40.38	54.75	1.438	2.188	0.06	-	-	-	-	-
Ginning roller	15.00	-	-	12.63	40.50	66.00	0.250	40.00	39.50	2.188	2.438	0.125	10.75	13.50
Continental Rotobar														
Stationary knife	6.00	5.75	8.26	0.032	0.9375	0.300	49.00	-	-	-	-	-	-	-
Rotary knife	2.75	2.625	45.00	9.813	48.50	62.625	1.437	1.938	0.031	-	-	-	-	-
Ginning roller	15.00	-	-	10.875	47.375	71.125	0.375	46.625	45.625	2.188	2.438	-2.75	12.75	13.50
Continental/Murray Phoenix Rotobar														
Stationary knife	6.00	5.75	8.26	0.032	0.9375	0.300	49.00	-	-	-	-	-	-	-
Rotary knife	2.726	2.625	45.00	11.313	48.50	65.313	1.437	1.938	0.031	-	-	-	-	-
Ginning roller	15.00	-	-	6.875	47.375	66.625	0.375	46.625	45.625	2.188	2.438	-0.625	10.50	13.50
Hardwicke-Etter HI-CAP														
Stationary knife	3.75	3.50	6.24	0.031	1.00	0.250	40.38	-	-	-	-	-	-	-
Rotary knife	2.75	2.625	45.00	3.875	40.25	54.5	1.438	2.188	0.063	-	-	-	-	-
Ginning roller	15.00	-	-	13.25	40.50	67.00	0.250	40.00	39.50	2.188	2.438	4.00	10.75	13.50
Lummus Rota-Matic 12400/13400/14400														
Stationary knife	3.75	3.50	6.24	0.031	1.00	0.250	40.38	-	-	-	-	-	-	-
Rotary knife	2.75	2.625	45.00	3.875	40.25	54.5	1.438	2.188	0.063	-	-	-	-	-
Ginning roller	15.00	-	-	13.25	40.50	67.00	0.250	40.00	39.50	2.188	2.438	4.00	10.75	13.50

[1]All values are in inches except for those in column B.

Between 1977 and 1979, spiral-type rotary knives were tested by the Agricultural Research Service, Southwestern Cotton Ginning Research Laboratory. The spiral knives operated with less vibration and improved the clearing of spindle-twist tags; however, the spiral knives did not increase ginning rate. Today roller ginneries use both the straight- and spiral-type knives.

The ginning roller is the most important and expensive component in the roller gin stand. Roller covering material is made from 13 layers of plain-woven cotton fabric cemented together with a white rubber compound. The fabric lays on the bias so that neither the warp nor the fill yarn are parallel to the direction of cutting; this arrangement prevents the material from unraveling from the roller surface. The roller material mounts onto the roller core with the cut edges of the fabric layers serving as the ginning surface. The roller material measures approximately three-fourths of an inch wide by seven-eighths of an inch thick and is available in either 30-ft-long coiled strips, which require splicing, or reels, which require no splicing. About 200 ft of roller material are needed to cover a 40-inch-long by 15-inch-diameter roller. The roller material hardness should be about 55–60 DO on a durometer scale; material of different hardness should not be used on the same roller, as unequal wear will occur. Material hardness changes with age and temperature; roller temperatures over 300 °F cause the roller covering material to deteriorate rapidly.

Rotary-Knife Roller Gin Stand Theory of Operation

Rotary-knife roller gin stands separate fiber from seed by frictional forces between a moving (roller) and fixed (stationary knife) surface. Three frictional forces exist when roller ginning cotton: (1) roller-to-stationary-knife, (2) roller-to-fiber, and (3) stationary-knife-to-fiber. During normal ginning, the roller-to-fiber force is greater than the stationary-knife-to-fiber force; therefore, the fiber sticks to the roller surface and slips on the stationary-knife surface. Also, the greater the force between the stationary knife and ginning roller, the greater the frictional pulling force between the fiber and ginning roller.

Cotton is ginned at the rate the cotton fibers (adhered to the roller surface) slip under the stationary knife. Overfeeding or feeding in bunches causes fiber and seed to tangle and stop at the stationary-knife edge; when stoppage occurs, roller surface is wasted, and the accumulated cotton is rejected as carryover by the rotary knife. Underfeeding results in areas of the roller surface being devoid of cotton; the roller uselessly slides on the stationary knife, thereby heating and wearing the roller surface.

Rotary-Knife Roller Gin Stand Adjustment

Recommended values of roller speed, rotary-knife speed, velocity ratio, air pressure, roller-to-stationary-knife (RSK) force, and knife-to-knife clearance for some representative gin stands are shown in table 10–2. A typical RSK force is 60 lb/inch of roller length (2,400 lb/40-inch gin stand). The RSK force resulting from the air cylinders deflects the stationary knife and its

Table 10–2.
Recommended operating parameters of several rotary-knife roller gin stands

Manufacturer and model	Roller speed		Rotary-knife speed			Velocity ratio	Air pressure	RSK force		Knife-knife clearance
	(rpm)	(m/sec)	(rpm)	(m/sec)	(strokes/sec)	roller/knife	(psi)	(lb/inch)	(kN/m)	(inches)
Consolidated Gin Co.	120	2.39	406[1]	1.48[1]	40.6	1.61	45	64.42	11.28	0.010
Continental Rotobar	110	2.19	240	0.878	24	2.49	90	69.41	12.16	0.032
Continental/Murray Phoenix Rotobar	117	2.33	380	1.38	38	1.69	90	69.41	12.16	0.032
Hardwicke-Etter HI-CAP	116	2.31	447	1.63	44.7	1.42	75–90	63.61	11.1	0.010
Lummus Rota-Matic 12400/13400/14400	116	2.31	447	1.63	44.7	1.42	75–90	63.61	11.1	0.010

[1]When roller gin stand is equipped with 4-bladed rotary-knife, rotary-knife speed = 605 rpm (2.21 m/sec).

holder; deflection must be controlled in order to maintain the proper stationary-knife-to-rotary-knife clearance. The knife-to-knife clearance is critical; maintaining the clearances within a small tolerance reduces both spindle twists and broken-seed-based lint tags at the stationary-knife edge.

The RSK force causes friction and heat on the roller surface. Most of the power driving the roller is converted to heat because of this friction. Roller surface temperature across the ginning roller indicates the uniformity of RSK force. Across the roller, the coefficient of friction can change and give misleading estimates of RSK force. During ginning, the cotton reduces the friction between the roller and stationary knife and absorbs some of the heat from the friction. Even when the flow of cotton is uniform, however, the roller surface temperature increases when the power driving the roller is increased. Roller surface temperature should be kept under 225 °F to ensure normal roller life.

Increasing the roller surface velocity and RSK force increases the ginning rate (Gillum 1985). Unfortunately, higher ginning rates require more input power, produce higher roller temperatures, and therefore require more attention from the ginner. Rotary-knife speed does not directly affect ginning rate; however, the tip velocity of the rotary knife should be different than the roller surface velocity to prevent trapping and crushing of the seed.

During ginning, seed cotton and ginned and partially ginned seed could accumulate on the stationary knife. But each stroke of the rotary knife clears the stationary-knife edge of accumulated seed cotton and seed, thereby restoring the effectiveness of the gin. Partially ginned seed is either pulled back to the stationary knife and completely ginned or swept along with the seed and carryover and later reclaimed. At the ginning point, about 45 percent of seed cotton trash goes with the lint, and the remainder goes with the seed. Dust liberated by the rotary knife is picked up by the dust hood. The rotary-knife barrier guards and safety interlocks must be used. The surface velocity of the rotary knife should be about 320 ft/min (1.63 m/sec).

The carryover reclaimer (figs. 10–7 and 10–8) removes unginned and partially ginned seed cotton and spindle twists from the seed flow and returns them to the distributor for ginning. The reclaimer usually cannot distinguish between seed cotton and spindle twists. Most of the spindle twists are returned and accumulate at the gin stand, resulting in reduced ginning efficiency and premature wear of the roller and rotary knife. Carryover percentage increases with feed rate but is typically less than 6 percent of the seed cotton fed (Gillum 1979).

The rotary knife and saw-type reclaimer are dangerous—a hand caught in either is severed instantly. Safety precautions must be followed when working near them. Gin employees should be particularly careful near the rotary-knife gin stands and saw-type reclaimers, since they are sometimes easily accessible.

Figure 10–7. Cross section of seed cotton reclaimer. *1*, Breaker cylinder, 1,005 rpm; *2*, Main saw cylinder, 449 rpm; *3*, Doffing brush, 1,005 rpm; *4*, Adjustable sheet; *5*, Reclaimed seed cotton inlet; *6*, Aspiration tube; *7*, Grid bars; *8*, Reclaimer saw cylinder, 340 rpm; *9*, Control bars (courtesy of Continental Eagle Corporation).

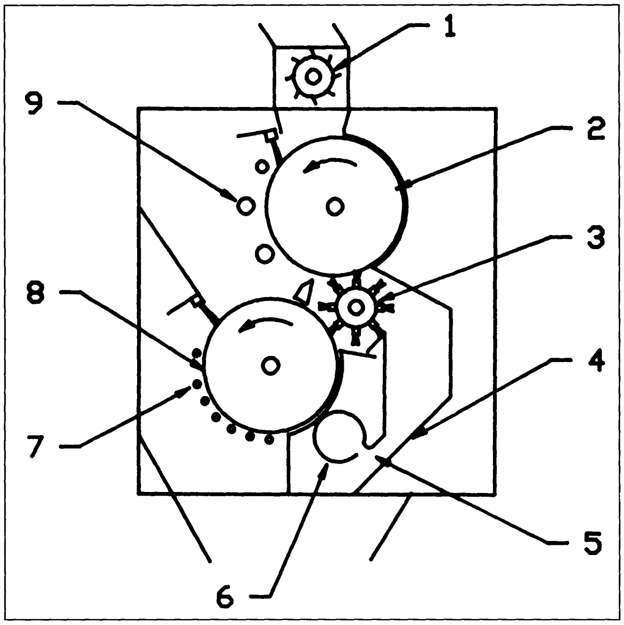
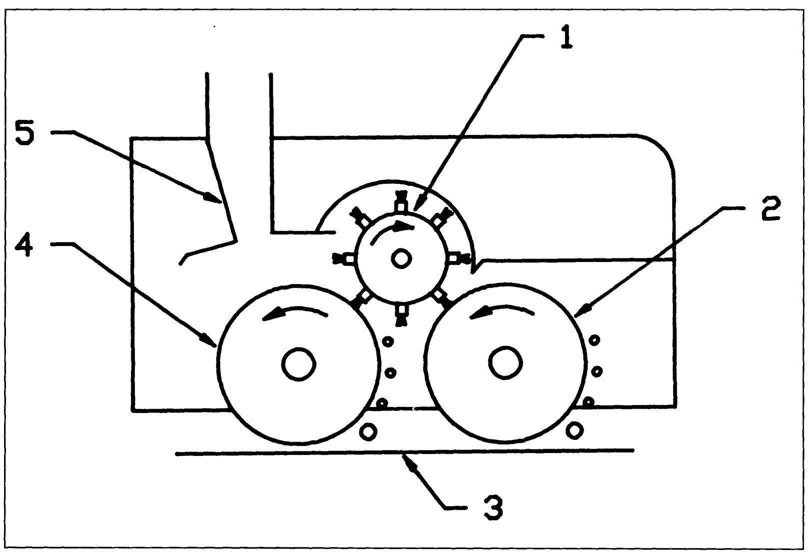


Figure 10–8. Cross section of seed cotton reclaimer. *1*, Doffing cylinder, 700 rpm; *2*, Second saw cylinder, 175 rpm; *3*, Seed drag belt; *4*, First saw cylinder, 175 rpm; *5*, Suction pickup deflector (courtesy of Lummus Corporation).



Lint Cleaning

In the past, the mill-type opener/airjet lint cleaner combination was used to remove motes, broken seed, entanglements caused by mechanical pickers, and small trash not removed in seed cotton cleaning (Alberson 1964). Because of their low capacity, many of the mill-type openers have been replaced by cylinder (incline) and revolving screen (impact) cleaners; the airjet cleaner is still used in combination with these cleaners. There is no standard machinery sequence for lint cleaning roller-ginned cotton today. But Hughs and Gillum (1991) found that lint cleaning in U.S. plants is performed by one of the following four machinery combinations: (1) two cleaners (incline or impact) and one airjet cleaner; (2) one cleaner (incline or impact) and one airjet cleaner; (3) two mill-type openers, each followed by an airjet cleaner; and (4) other. These 4 machinery combinations are used in 24, 14, 4, and 4 gin plants in the United States, respectively. The most common lint cleaning sequence is an incline, impact, and airjet (combination one); 35 percent of gin plants have such an arrangement. Lint cleaning efficiency for U.S. gins ranged from 13 to 62 percent, with combination-one efficiency averaging 34 percent. The average classers' grade improves from 3.4 to 2.9 following lint cleaning. Figures 10–9 through 10–12 show lint cleaning systems recommended by different manufacturers.

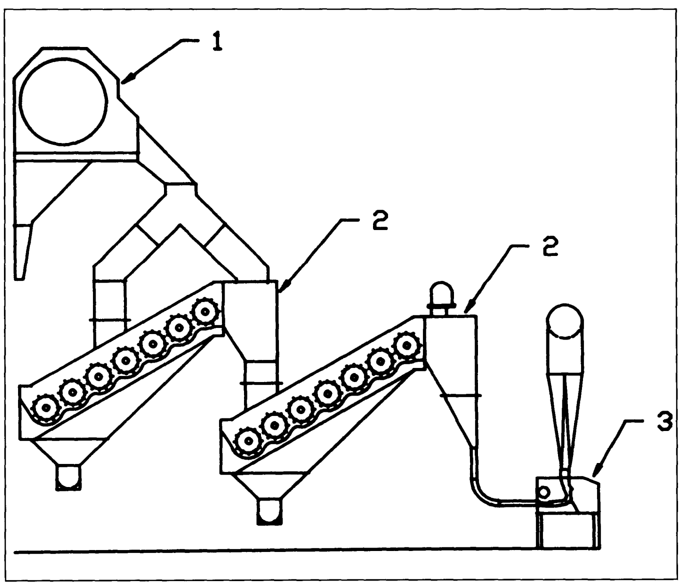


Figure 10–9. Lint cleaning system recommended and made by Consolidated Cotton Gin Co., Inc. *1*, Lint-cleaner condenser, 86-inch; *2*, Gravity cleaner, 96-inch; *3*, Super mote cleaner, 84-inch (courtesy of Consolidated Cotton Gin Co., Inc.).

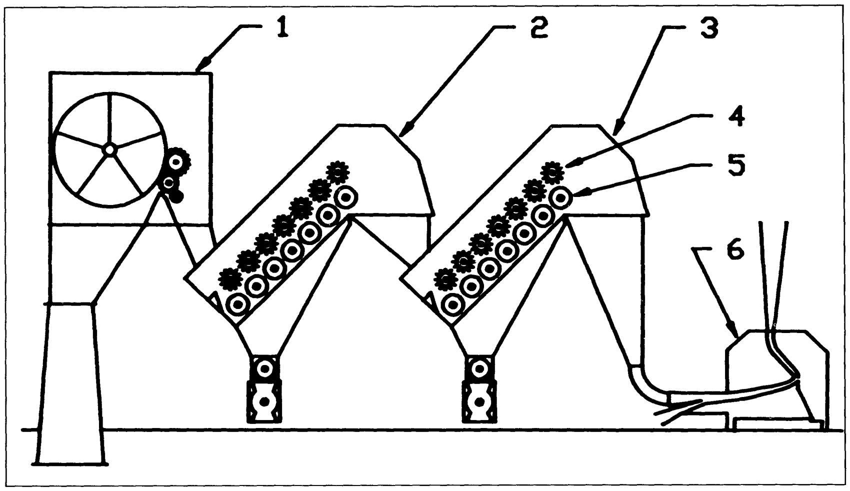


Figure 10–10. Lint cleaning system recommended and made by the Continental Eagle Corporation. *1*, Condenser; *2*, Impact lint cleaner; *3*, Impact lint cleaner; *4*, Spiked cylinder, 676 rpm; *5*, Saw cylinder, 460 rpm; *6*, Centrifugal lint cleaner (courtesy of Continental Eagle Corporation).

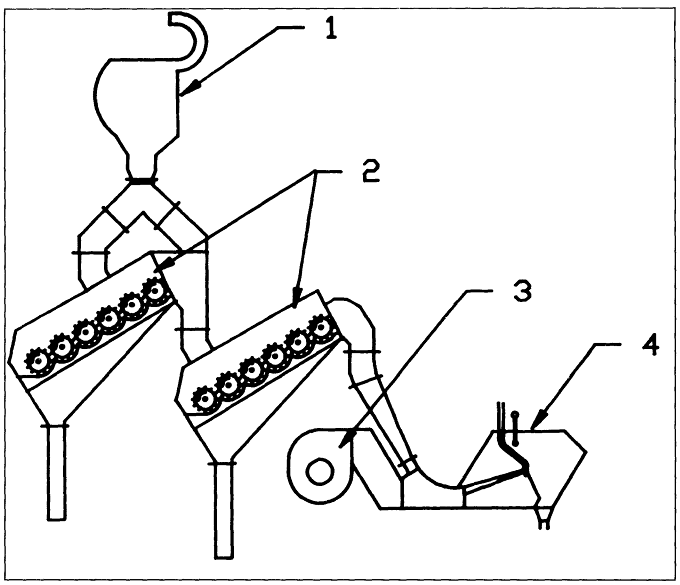
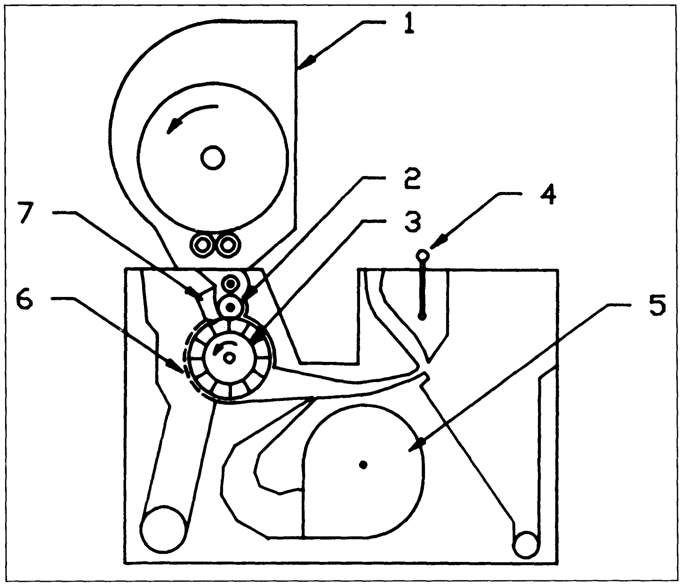


Figure 10–11. Roller gin lint cleaning system offered and made by Lummus Industries, Inc. *1*, Lint cleaner condenser; *2*, Six-cylinder gravity cleaner, 96-inch; *3*, Booster fan; *4*, Super-jet™ cleaner, 94-inch (courtesy of Lummus Corporation).

Figure 10–12. Guardian™ lint cleaning system recommended and made by Lummus Industries, Inc. *1*, Drum condenser; *2*, Main feed roller; *3*, Beater cylinder; *4*, Adjustment lever; *5*, Booster fan; *6*, Grid rack; *7*, Feed plate (courtesy of Lummus Corporation).



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Safety and Health of Gin Workers

D.L. Roberts, R.V. McManus, R. Shanoian, and D. Smith

Accidents, Injuries, and Costs

The cotton ginning industry, like other processing industries, has many hazards. While the industry has been active in hazard reduction and safety education, gin safety remains a major concern. The reasons for the concern include the high frequency of accidents and workers' compensation claims, the large number of lost work days, and the severity of the accidents (Safety and Health Committee 1984).

Total economic costs for gin injuries and health disorders include direct costs (medical and other compensation) and indirect costs (time lost from work, downtime, loss in earning power, higher insurance costs for workers' compensation, loss of productivity, and many other loss factors). Direct costs are easier to determine and much less expensive than indirect costs.

Claims information from a principal insurance carrier of gins in Southeastern States and Texas is indicative of the seriousness of the problem. Table 11–1 summarizes 1,231 of these claims. The body part injured most frequently was the hand/fingers, followed by the back/spine, eye, foot/toes, arm/shoulder, leg, trunk, and head.

Table 11–1 shows that the most frequent accident type involves being struck by or against an object, followed by straining/overexerting, being caught in or between objects, slipping/falling, and being hit by flying objects. The highest average cost per claim was from being caught in or between something, followed by slipping/falling, straining/overexerting, and being in contact with electricity.

A summary of claims for gins in the Lubbock District for the 1984–87 seasons is shown in Table 11–2. These data represent 80 gins in 1987, 100 in 1986, 150 in 1985, and 144 in 1984. The annual claim losses averaged $9,466 per gin, and the average number of claims per gin was 1.97. The average claim cost was $4,805. The loss ratio is a ratio of the claims costs (losses) to the premiums. It is often expressed as a percentage. The loss ratios for these claims data were 70.1 percent in 1987, 137.8 percent in 1986, 84.5 percent in 1985, and 65.1 percent in 1984, for a 4-yr average of 86.3 percent. The claim frequency in the Lubbock District has been considerably higher than the industry average for the State. The cost of accidents becomes critical when both the frequency and severity of claims are high, making the loss ratio skyrocket. The average claims cost during 1984–1987 was 99 percent higher (a 16.5-percent annual increase) than that for 1981. Most of the increased claims cost was due to increases in hospitalization, medical care, and legal costs.

Accidents should be analyzed using man hours of work as a basis for gin comparisons. Incidence rates can be determined by first multiplying the number of injuries (or lost work days per case or total days lost) times

Table 11–1.
Frequency and claims costs of various accidents

Accident type	Number	Average cost per claim	Relative cost per claim[1]
Caught in or between objects	158	$ 7,888	1.3
Contact with electricity	3	6,267	1.1
Contact with temperature extreme	5	3,367	0.6
Explosion/flashback	6	4,319	0.7
Fall/slip	154	7,059	1.2
Hit by flying object	123	2,118	0.4
Inhale/absorb/swallow something	9	1,201	0.2
Strain/overexertion	175	6,718	1.1
Struck by or against an object	443	3,873	0.7
Other	155	11,121	1.9
Total	1231	Overall average $ 5,915	

[1]Ratio of the average cost per claim for a particular accident type to the overall average cost per claim.

Sources: Ronald R. Gleghorn (personal communication, Lubbock District engineering manager, Employers Insurance of Texas, Lubbock, TX) and Vern E. Wilfong (personal communication, Birmingham District engineering manager, Employers National Insurance Company, Birmingham, AL).

200,000 and then dividing by the total hours worked by all employees in the operation during the calendar year.

In general the following can be concluded:

1. Gin accidents produce many permanent injuries and some deaths.

2. While lint cleaners, gin stands, and presses are involved in a number of severe accidents, many other machines, equipment, and materials have the potential for producing severe injuries. All gin machinery should be used with caution.

3. It only takes a few severe injuries or deaths to cause the average cost per case and loss ratio to increase significantly. The result is increased insurance costs for workers' compensation. Twelve of the 934 claims in table 11-2 were for $50,000 or more. In 1985 an insurance carrier for Midsouth gins reported 14 claims costing over $20,000 and 5 over $50,000 for that year. Some exceeded $100,000 when settled. The most frequent high-expense accident type was getting a hand or arm caught in a lint cleaner or gin stand. Other high-expense claims included

Table 11–2.
Injury claims and costs submitted from the Lubbock District to a gin insurance carrier during 1984–1987

Injury causal agent or occupation of injured employee	Claims			Average cost per claim	Relative cost per claim[1]
	Number	Percent			
Causal agent					
Lint cleaner	32	3.4		$ 11,492	2.4
Gin stand	72	7.7		3,448	0.7
Press	163	17.5		4,053	0.8
Other gin machines	62	6.6		6,224	1.3
Belts/chains	30	3.2		3,137	0.7
Auger/conveyor	16	1.7		5,072	1.1
Ladder/scaffold	23	2.5		40,473	8.4
Tractor/trailer/module	49	5.2		3,795	0.8
Truck	83	8.9		4,510	0.9
Cotton bale	57	6.1		6,338	1.3
Occupation					
Suction	62	6.6		1,752	0.4
Ginners/helpers	117	12.6		1,599	0.3
Management/supervisor	24	2.6		2,910	0.6
Cotton seed	2	0.2		115,938	24.1
All other	61	6.5		1,677	0.3
Repair	81	8.7		1,182	0.2
Total	934	100.0	Overall average	$ 4,805	

[1]Ratio of the average cost per claim for a particular agent or occupation to the overall average per claim.

Source: Ronald R. Gleghorn (personal communication, Lubbock District engineering manager, Employers Insurance of Texas, Lubbock, TX).

serious falls, heart attacks, electrocution, and getting struck or crushed by materials.

4. Gin yard accidents also produce some serious injuries and significant costs. These accidents include falling or jumping from a trailer or module. Other injuries occur to operators of suction equipment. Tractor-related injuries result from falling, hitching, overturning, and towing. Seed cotton fires in trailers or modules can be extremely dangerous. While fires produce few injuries in the yard, the seriousness of these injuries is such that fires must be prevented.

Loss Control

Each gin should have a loss control program to protect the safety and health of workers and the economic health of the business. A good loss control program includes seven elements to prevent accidents and health disorders and to minimize the losses from these should they occur. These elements were described by Price (1988) as follows:

1. Provide management leadership.
2. Assign responsibility for safety to managers and employees.
3. Maintain a safe and healthful working environment.
4. Provide employee job and safety training.
5. Create employee safety awareness programs; motivate employees to participate.
6. Provide adequate first aid and medical assistance.
7. Take steps to prevent accidents from recurring.

Since each gin operation is unique, the activities involved in fulfilling each of these seven elements will vary. When developing a loss control program, management should consider the characteristics of the entire gin operation—the equipment, structures, employees, transportation, storage, and Federal/State/local regulations affecting the operation. While the following does not list the contents of a complete loss control program, it gives some examples and guidelines for each element.

Safety Rules

The following procedures should be used to keep the gin machinery and facilities safe (McManus 1980):

1. Do not operate machinery having worn parts, cracked belts, or defective chains. Tighten loose fittings and couplings. If an unsafe condition cannot be corrected or repaired immediately, bring it to the attention of employees who will be working in the area.
2. Keep basic first aid supplies in a dust-tight enclosure and make them readily available to all employees.
3. Cover line shafts and conveyors that cross normal walkways. Cover those which cross at floor level with removable grids or plates that will support a minimum weight of 250 lb.
4. Locate firefighting apparatuses in accessible, clearly marked areas. At each location place extinguishers for petroleum, textile, and electrical fires (type ABC). Inspect the condition of extinguishers frequently.

5. Guard all belt gear and chain transmissions that are less than 7 ft above the ground or working surface. Guards should be strong enough to not give way or collapse when leaned on or shoved against. See figure 11–1 for a sample checklist for guarding power transmission equipment and figure 11–2 for a checklist for guarding functional components.

6. Use barriers between gin stands to guard drives and prevent accidental or intentional access into the areas.

7. Make sure that projecting shaft ends have smooth edges and do not project more than one-half the diameter of the shaft unless guarded by nonrotating caps or safety sleeves.

8. Provide gin stands with a permanently installed guard designed to preclude contact with moving gin saws.

9. On lint cleaners having access doors to the saws, put bar- or grid-type barrier guards that will prevent finger contact with saws.

10. On all bale presses, install a device to prevent the upper gates from being opened while the tramper is operating.

11. Put hinges and a positive latch on each top panel of bur extractors.

12. In all gins install a warning device that will sound an audible signal before the machinery is started.

13. Equip catwalks and other elevated work surfaces or passageways with guardrails and toe boards. When constructing guardrails, install a top rail 42 inches above the work surface and install a midrail. Use toe boards 2–6 inches in height on surfaces elevated 6 ft or more.

14. For stair rails, install the top rail 30 inches vertically above the nose of the tread and install a midrail.

15. Do not use ladders that will not support a minimum concentrated load of 200 lb at each rung. Provide cages on ladders that are more than 20-ft high.

The following procedures should be used by employees and managers to ensure their safety:

1. Wear comfortable, close-fitting clothes. Wear sleeves that fit snugly at the wrists, and do not roll up sleeves. Do not wear gloves around moving machinery parts. (Tight-fitting gloves should be worn by the press crew to prevent serious cuts.)

2. Treat scratches, cuts, minor scrapes, and sprains immediately, and seek professional care for major injuries. Make sure that each shift has at least one employee (but preferably two) trained in a certified first aid course.

Figure 11–1. Sample of safety checklist for guarding power-transmission gin machinery

Date________________

Machine or device [OSHA regulation number[1]]	Three authorized methods of guarding:		
	Put in remote location	Use shield or barrier	Use railings
Gin stand drives [1928.57 d(1)i] Safe: Yes ( ) No ( )	Drives higher than 7′ do not require guards.	Guard both sides up to 7′ high. Put shields on ends, barrier between stands.	Use rails where shield would interfere with controls.
Flat belts [1928.57 d(1)iii] Safe: Yes ( ) No ( )	No guards required if over 7′ above work surface and 7′ away from ladders or stairs.	Belt drives must be minimum of 15" from railings or be individually guarded by shields or barriers.	Use 42" rail with midrail. Rails must withstand 200 lb top-rail pressure at any point.
Pulleys of V-belt drives [1928.57 d(1)iv] Safe: Yes ( ) No ( )	No guards required if over 7′ above work surface and 7′ away from ladders or stairs.	Complete enclosure preferred. Open end of guard shall be not less than 4" from periphery of pulleys. Inside of guard must extend far enough to prevent contact.	Use rails only where drives can be isolated in power development room.
Chains, sprockets [1928.57 d(1)v] Safe: Yes ( ) No ( )		Completely enclose.	
Components with excessive lint deposits [1928.57 d(1)vi] Safe: Yes ( ) No ( )		Use shield 6" beyond in-running & off-running sides of belt, 2" from rim and face of pulley in all directions.	
Shaft ends [1928.57 d(1)vii] Safe: Yes ( ) No ( )	No guards required if over 7′ above work surface and 7′ away from ladders or stairs.		
Power development room [1928.57 d(1)viii] (Can be constructed in existing buildings with adequate walls, limited access.) Safe: Yes ( ) No ( )		Drives must be minimum of 15" from railings or be individually guarded by shields. Post sign stating "AUTHORIZED PERSONNEL ONLY" on entrance to room.	<u>**All drives**</u>**:** Require 42" top rail with midrail; rails must withstand 200 lb top-rail pressure at any point.

[1]OSHA regulation numbers listed in brackets are from 29 CFR 1928 in Occupational Safety and Health Standards for Agriculture.

Figure 11–2. Sample checklist for guarding functional gin components and warning devices

Date ______________

Machine [OSHA regulation number[1]]	Method of guarding
Gin stands [1928.57 d(2)i] Safe: Yes ( ) No ( )	Older models require guard to preclude contact under stands during cleaning and unclogging while saw is in motion. Saws in roll box are guarded by their location if they do not extend through ribs when breast is in out position.
Lint cleaners [1928.57 d(2)ii] Safe: Yes ( ) No ( )	Moss lint cleaners and other models that can be operated with doors off or with open areas at the saw cylinders can be equipped with barrier guards made from horizontal rods spaced close enough to prevent finger contact with saws. These guards permit a stick or air nozzle to be used. Cleaners with doors that open into saw areas and that must be closed during operation require a device to prevent access until saw shaft stops.
Tramper [1928.57 d(2)iii] Safe: Yes ( ) No ( )	Require interlock device that will either stop tramper when upper gate is opened or prevent door from being opened while tramper is moving.
Burr extractors [1928.57 d(2)iv] Safe: Yes ( ) No ( )	Top panels or hatches must be hinged on one side and secured by sturdy latch on other side.
Screw conveyors [1928.57 d(2)v] Safe: Yes ( ) No ( )	Solid covers, gratings, or horizontal bars must be spaced to prevent contact and still allow material to be fed into conveyor. Conveyors under gin stands can be guarded by their location.
Warning device [1928.57 d(3)] Safe: Yes ( ) No ( )	Horn, buzzer, and bell must be sounded before machinery is started. These devices can be installed in starting sequence to prevent accidental start without warning or be wired separate from other controls.

[1]OSHA regulation numbers listed in brackets are from 29 CFR 1928 in Occupational Safety and Health Standards for Agriculture.

3. Keep all work areas free of trash, debris, tools, and any objects that obstruct safe and normal passage. Return all tools to designated storage areas or racks as soon as they are no longer needed.

4. Clean up oil and grease slicks.

5. Permit only qualified personnel to repair and adjust machinery.

6. Make sure that fellow employees are clear of machinery before power is turned on. Use the lockout system to prevent accidental starting of machinery when repairs are in progress.

7. After repairs have been performed, see that all guards and covers are replaced before a machine is started.

8. Stop machinery before changing belts. Do not take belts on or off while machinery is running; instead roll them onto pulleys and flywheels by hand. Use extreme caution.

9. Raise the gin breast before dumping seed rolls. Rake out the seed with a stick when the rolls are dumped.

10. On air blast gins, stop the stand before cleaning the air nozzles. Do not operate a gin stand having exposed saw cylinders.

11. Keep fingers away from saw cylinders. Use sticks, air hoses, or other extension tools around saws. When work on saws is necessary, shut off and lock out the electrical power. Remove or open panels, doors, or guards only after the saw shafts have stopped turning.

12. Keep press doors closed until the ram stops. Do not clean the tramper foot unless the power has been locked out.

13. Watch the turning press carefully and warn employees in the area when the press moves. Push the presses that are not equipped with power turning devices with hands and not shoulders.

14. Use ladders to enter and exit trailers. Do not attempt to guide the trailer tongue by hand, and keep your feet clear while handling the tongue. Maintain close visual coordination between tractor driver and yardman when trailers are being hooked, moved, or parked.

15. See that motors are shut off before refueling vehicles.

16. Permit no riders on yard tractors other than the operator.

17. Wear eye protection (goggles or glasses) when blowing down the gin with air and when cutting or grinding.

18. Wear ear protection (ear plugs, ear muffs) while the gin is running.

19. Wear dust respirators when cleaning the gin or performing other operations that produce dust.

20. Wear all safety equipment issued to you. Failure to do so could result in termination of your employment.

21. Lock lint cleaner and module feeder doors before running the gin.

22. Follow lockout procedures at all times during maintenance.

23. Before starting the gin, lock all guards having locks and give the keys to the ginner.

24. Do not stand, walk, or climb on ceiling pipes or rafters when the gin is running; instead, use the catwalks (for standing or walking). Use a safety belt and lanyard secured to a substantial anchor when accessing elevated locations outside a railed platform.

Procedures for Gin Fires

When a fire occurs, the ginner and press operator should do the following:

Ginner:

1. Sound the horn several times with many rapid blasts to alert the press man and the rest of the crew.

2. Kick out the gin stands.

3. Open all fire doors.

4. Stop the flow of seed cotton from the feed control or module feeder.

5. Shut off all heaters, V-trench conveyors, and seed conveyors.

6. Kick in the fire door at the gin stands.

7. Attach a tarp on each gin stand.

8. Run cotton from the feeder apron out onto the floor. Gin all cotton before shutting the gin down.

9. Wet down all burning cotton on the floor.

10. Move all the burned cotton to the outside of the gin, and put the cotton next to a water supply.

11. Shut down all gin equipment for cleanout.

Press operator:

1. Stay with the press and battery condenser until the fire is out.

2. Wait until all cotton is down the slide, and then turn the press and raise the bale out of the press.

3. Keep the tramper running if cotton is burning in the lint slide.

4. If a fire is in the battery condenser, wet down the areas around the flashing and rollers, and avoid letting the fire burn on the lint belt or near the flashing.

5. Isolate at least two bales before and after a suspected bale fire.

Other crew members:

The lint cleaner operator should stay with the lint cleaners until the fire is completely out. The moteman/yard operator should move the mote trailer out from under the shed. The module feeder operator should move the module away from the spike rollers to stop feeding seed cotton into the gin. All other crew members should report to the ginner. Only water should be used to put out cotton fires. Chemical fire extinguishers should be used on oil, gas, and electrical fires only.

Management Leadership

To establish an effective safety program, management must do the following:

1. Set a good example.

2. Develop a gin safety policy that reflects the management's philosophy.

3. Develop specific written objectives that are clear and realistic.

4. Develop a set of written safety rules that incorporate applicable Federal/State/local safety and health regulations.

5. Assign responsibility to supervisors and others.

6. Be involved—discuss safety (including costs/benefits) and motivate employees to follow safety rules.

Management must ensure that safety and health rules are followed by all employees. Both written and oral safety instructions should be provided in Spanish or other languages as necessary. To get help in establishing or improving your program, contact your gin insurance carrier, ginners' association, or the safety specialist with the Cooperative Extension Service.

Most safety and health regulations affecting cotton ginning are derived from Federal acts administered by the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency. The California ginning industry is an exception, since it must meet more stringent State regulations.

Gin employers are required by OSHA to

1. Furnish a place of employment that is free from recognized hazards that are likely to cause death or serious physical harm.

2. Maintain records on recordable occupational injuries and illnesses of employees. Forms and posting requirements are contained in the U.S. Department of Labor's latest revision of "Record-Keeping Requirements Under the Occupational Safety and Health Administration of 1970."

3. Display the OSHA Poster that explains the protection and obligations of employers and employees under OSHA.

4. Guard gin machinery, and install a warning device in accordance with OSHA regulations 29 CFR 1928.57(d). Figures 11–1 and 11–2 are checklists that can be used to determine whether a gin complies with these regulations.

5. Train employees in accordance with OSHA regulations 29 CFR 1928.51(d) for tractor operations and 1928.57(a)(6) and 29 CFR 1928.57(d)(1)(viii) for operating and servicing gin equipment.

6. Transmit information on hazardous chemicals to employees (see specifics in OSHA's hazard communication standard, 29 CFR 1910.1200).

In August 1987, OSHA promulgated an expanded hazard communication standard, Federal Register 52(163):31852-31886, that covers all industries, including ginning and farming. This standard requires information on hazardous chemicals to be transmitted to employees through labels, material safety data sheets, and training programs. Each gin must also have a written hazard communication program and must keep records. Compliance by ginning and other nonmanufacturing sectors was required as of August 1, 1988 (Johnson 1988).

Other agricultural OSHA regulations may apply to a gin, including (1) the need for slow-moving vehicle emblems on trailers/tractors operating on public roadways, (2) a provision for rollover protective structures on tractors operated by employees, and (3) a provision for proper living facilities for temporary labor. While gins are considered agricultural enterprises and are not specifically covered by many regulations, ginners will likely want to conform to other regulations in OSHA's "Standards for General Industry, Part 1910." There are three specific OSHA standards that ginners should consider, including those for fire and other emergency plans (29 CFR 1910.38a), exits (29 CFR 1910.35–.40), and occupational noise exposure (29 CFR 1910.95). Major exit requirements are given in 29 CFR 1910.36 and 29 CFR 1910.37.

OSHA specifies a maximum allowable exposure of 8 hr/day to a continuous 90-dBA noise level and a halving of the exposure time for each 5-dBA increase. This means a maximum exposure of 4 hr/day to a continuous 95-dBA level and so on to 30 min/day to a continuous 110-dBA level.

Since workers are exposed to different levels of noise for different lengths of time during the day, OSHA specified a way to measure noise throughout the day to get a time-weighted average for the noises. Noise exposure during an 8-hr shift can be easily obtained by placing a dosimeter on the employee to measure exposure during the workday. This figure can then be compared to the OSHA allowable levels. Corrective actions should include engineering or administrative controls if the 8-hr exposure is 90 dBA or greater and hearing conservation measures if the 8-hr exposure is 85 dBA or greater. All hearing protection devices (plugs, muffs) provided by management should be OSHA approved.

Contact your State Department of Health and the Cooperative Extension Service for information on pollution regulations. For more details on safety regulations, contact your nearest OSHA office, State Department of Labor, Cooperative Extension Service, or ginners' association.

Assignment of Responsibility

Every employee has a responsibility to follow safe and healthful work practices and to look out for co-workers. Management must assign responsibility and authority to key individuals, usually supervisors, and must expect and motivate them to set a good example.

The following is a list of some of the supervisor's duties and responsibilities relating to worker safety:

1. Provide leadership.

   a) Show interest in safety so that employees will be safety conscious.
   b) Promote safety to subordinates.

2. Provide safe working conditions (safe environment).

   a) Analyze work area hazards.
   b) Correct unsafe conditions and unsafe acts or practices.

3. Maintain orderly, well-kept work areas.

   a) Provide adequate storage space.
   b) Teach employees to work in an orderly manner.

4. Provide safety instruction on the following:

   a) Being aware of general hazards and of safe methods of doing specific jobs

b) Avoiding unsafe practices
c) Handling materials properly (lifting, stacking, etc.)
d) Using guards properly
e) Working neatly
f) Wearing safe clothing and using protective equipment properly
g) Giving prompt attention to all injuries, minor or otherwise.

5. Set a good example—motivate!

6. Act on fundamental principles of safety.

   a) Develop a list of hazards for each work area, and instruct workers about these hazards.
   b) Use inspection forms that require systematic and thorough inspections for neatness and unsafe acts or conditions.
   c) Issue necessary orders, and make sure the orders are carried out.
   d) Know the safety rules and enforce them.

7. Take definite action on willful violation of safety rules.

8. Make good, comprehensible accident reports.

   a) Analyze past reports and safety records to help avoid accidents in the future.
   b) Compare reports and safety records among work areas and within the industry.

9. Cooperate with others to bring about a good safety program.

   a) Attend safety meetings; occasionally conduct the meetings.
   b) Standardize procedures.

10. Check employees' past safety and health records to prevent placing persons in positions for which they are either mentally or physically incapable.

11. See that the injured receive proper care.

The three basic causes of accidents are lack of knowledge or skill, improper attitude, and failure to follow safe practices. All of these causes can be overcome if the supervisor fulfills his responsibilities in the safety program.

Maintenance of Safe Working Environment

A safe working environment can be achieved by periodically inspecting for physical hazards and eliminating them; by performing preventive maintenance on machinery, structures, equipment, and tools; and by keeping the gin neat and clean (good housekeeping).

Checklists are helpful to identify specific items/areas in a gin that must receive scheduled inspection and maintenance. Checklists should be specific to the gin operation. Figure 11–3 shows a sample checklist.

Preventive maintenance and good housekeeping are essential to an effective loss control program because they increase production and help reduce the chance of fires, property loss, and injuries due to accidents. In addition to cleanliness, good housekeeping also means an orderly flow and arrangement of all materials. The following is an example of gin housekeeping procedures that include some preventive maintenance:

1. Clean floor and coffee area daily.

2. Empty trash cans.

3. Clean heater screens.

4. Clean restrooms each shift.

5. Check magnets when gin is shut down.

6. Clean air compressor air filters.

7. Empty barrels under rock catcher.

8. Blow out all motors at least every other day.

9. Blow down gin each shift, including all catwalks.

10. Clean the following daily: battery condenser, lint flue, lint cleaners, extractor feeders (back and front), incline cleaners, conveyor distributor, V-trench and seed conveyors, field control paddles, oil chains (when needed), and air conditioner filters.

11. During downtime, clean the following: all pits, seed cotton separators, air line separators, lint cleaner fans, humid air units, and the seed blower filter.

12. Also during downtime, do the following: Check for wads in tower dryers, blow down gin, blow out motor brakes, clean counter flow belly and check vacuum, and oil chains in seed pit.

Employee Training

Safety and health instruction should be a normal part of all training for new and experienced employees facing new tasks and for employees having job performance problems. All employees should periodically have refresher courses in safety and health. Such instruction should include an analysis of the hazards associated with each job. Training information (written and spoken) should be positive, simple, and easy to understand.

Figure 11–3. Sample maintenance checklist for gins

Gin: ______________ Date: ______ By: ______________________________
Description of machinery: ________ Stands: ______________________________
Saws: ________________________ Press: ______________________________
Lint cleaners: ____

Place a check mark below next to those items that are substandard. Describe problem in the area to the right of checked items.

Gin Stands and Feeders:
- ( ) Saws on left side
- ( ) Saws on right side
- ( ) Saws under breast
- ( ) Saws over breast
- ( ) Saws in the rear
- ( ) Reclaimer saw
- ( ) Main drive
- ( ) Drives between stands
- ( ) End drive of No. 1 stand
- ( ) End drive of last stand
- ( ) Rear drives between stands
- ( ) Rear end drive of No. 1 stand
- ( ) Rear end of last stand
- ( ) Rear feeder drive at catwalk
- ( ) Trash and seed auger
- ( ) Saw mote auger
- ( ) Trash chute cover
- ( ) Levers
- ( ) Electrical controls
- ( ) Warning stickers

Ground Level Stick Machine/Burr Machine:
- ( ) Burr/stick machine drives
- ( ) Floor plates
- ( ) Air compressor drives
- ( ) Big reel drives

Elevated Separator, Inclined Cleaner, Impact Cleaner:
- ( ) Suction separator drives
- ( ) Catwalk platform
- ( ) Catwalk railing
- ( ) Fixed ladder
- ( ) Inclined cleaner (Incl. cl.) drives
- ( ) Incl. cl. platform
- ( ) Incl. cl. railing
- ( ) Incl. cl. ladder
- ( ) Incl. cl. dr. (over stands)
- ( ) Incl. cl. platform (o/s)
- ( ) Incl. cl. railing (o/s)
- ( ) Incl. cl. ladder (o/s)
- ( ) Overflow separator drives
- ( ) Catwalk platform
- ( ) Catwalk railing
- ( ) Fixed ladder
- ( ) Counterweight protection
- ( ) Top-center catwalk

Bale Press:
- ( ) Lint gate interlock
- ( ) Tramper flashing
- ( ) Trap door
- ( ) Hoist safety latch
- ( ) Sample saw stops
- ( ) Stickers
- ( ) Bagging conveyor drives
- ( ) Pusher
- ( ) Lockable controls

Console:
- ( ) Padlock adapters
- ( ) Master stop
- ( ) Horn

Motion Control Center:
- ( ) Padlock adapters
- ( ) Identification labels

Outside:
- ( ) Seed loader
- ( ) Cyclone access
- ( ) Tractor rules
- ( ) PTO

Miscellaneous:
- ( ) Portable ladders
- ( ) Safety equipment box
- ( ) Bulletin board
- ( ) Ladder door interlock
- ( ) Tower dryer ladder
- ( ) Ladder door (AZ)

Lint Cleaners:
- ( ) Saw doors bolted
- ( ) Front feed roll guards
- ( ) Rear feed roll guards
- ( ) V-belt drives

Mote Cleaners:
- ( ) V-belt drives
- ( ) Moving cleaner parts

Comments:

Employers should make sure that new employees are familiar with the proper use of personal protective equipment and with the safety rules of the gin. In doing so, employers can use a checklist similar to the one in figure 11–4.

Reducing the anxiety of employees, particularly new ones, is important to safe ginning. Anxiety can be reduced by putting employees at ease and doing the following:

1. Take time to learn what they know about the job, and stress the importance of the job.

2. Present the job or procedure by telling, showing, and illustrating. Stress key points and encourage discussion.

3. Give employees performance tryouts when they do a job for the first time. Ask specific questions about tasks. Correct any errors and misunderstanding until their performance is acceptable.

4. Tell them whom to go to for help, frequently check with them once they are put on their own, and reduce their supervision to normal after their performance improves.

Job instruction is necessary to reduce hazards and injuries. Videotapes on safety are available from the National Cotton Ginners' Association, P.O. Box 12285, Memphis, TN 38182. Short, weekly safety meetings should be held to refresh each crew or shift.

Employees in high-hazard jobs and in important safety operations should receive extra training. For example, employees involved in locking out equipment (before another employee cleans, unplugs, repairs, or maintains it) should be trained thoroughly. This training material should be written step by step, and supplemental photos can be used to assist training.

Job hazard analysis is an important part of employee training and loss management. This training tool involves four steps and is an effective way to actively involve employees in the safety program. The four steps involve breaking down the job, identifying the hazards, taking measures to eliminate or decrease hazards, and evaluating the efficiency of corrective measures.

First Aid and Other Medical Assistance

Proper medical care should be provided to all employees. The medical program should include preemployment medical screening, a plan for preventing occupational health disorders, procedures for reporting and caring for injuries and illnesses, and a plan for emergencies. The program will help minimize losses due to injuries and health disorders. Employers should determine the medical condition of each prospective employee to minimize hiring those with preexisting health disorders and chronic injuries. While a physical examination should uncover medical problems, it is wise to have all

Figure 11–4. Sample safety checklist for new employees

CHECK

1. Use of personal protective equipment

_______ A. Safety hat
_______ B. Goggles-safety glasses
_______ C. Dust mask
_______ D. Gloves
_______ E. Ear protection
_______ F. Work shoes
_______ G. Safety belts

2. Knowledge of general safety rules pertaining to

_______ A. Smoking/no smoking areas
_______ B. Blowing off clothing with compressed air
_______ C. Walking/working surface above ground level
_______ D. Removal and replacement of guards
_______ E. Loose clothing
_______ F. Special safety procedures for unchoking machinery
_______ G. Lockout procedures
_______ H. Housekeeping
_______ I. Proper lifting
_______ J. Fire protection & prevention—emergency action plan
_______ K. Use of tools
_______ L. Prompt reporting of accidents
_______ M. Use of ladders
_______ N. "If in doubt—ask first"
_______ O. Disciplinary action
_______ P. Forklifts
_______ Q. Welding
_______ R. Tractor operating
_______ S. Other (special plant rules)

Date: ______________________ Supervisor: ______________________

Employee: ______________________

By signing, the employee verifies that he/she has received training on the above checked items from his/her supervisor.

prospective employees complete a preemployment medical questionnaire. Prospective employees must be briefed on physical work requirements such as standing, lifting, and climbing and on the hazards of potential irritants such as dust, heat, cold.

Each gin should establish a clear procedure for reporting injuries and illnesses. All employees should know and understand it. Emergency telephone numbers should be posted at prominent and designated locations. At least two employees per shift should have first aid training so that they can give basic care for severe injuries and can give cardiopulmonary resuscitation, particularly if the gin is far from emergency medical facilities.

Employee Participation in Safety Programs

The most effective loss control programs are those in which management motivates employees to be safety conscious. This motivation can be accomplished by establishing a safety policy that gets the employees involved in each element of the program, by participating in safety training, by setting a good example, and by providing employees with appropriate incentives.

Occupational health disorders are lessened by requiring a) the use of personal protective equipment (PPE) in designated areas and b) that employees observe acceptable work practices.

Hearing (plugs or muffs) and breathing (dust mask) PPE should be used by those working in areas having high noise or dust levels. Some people are more susceptible to noise and respiratory problems than others, and even with PPE should be reassigned to work areas with lower noise or dust levels. Health hazards associated with heavy lifting and excessive heat can be handled by training, use of materials handling equipment, proper dress, ventilation, and breaks from the heat.

All persons throughout the gin operation must be involved in gin safety. A safe work atmosphere can be established when everyone is motivated to participate fully in the loss control program.

Preventing the Recurrence of Accidents

After an accident occurs, management should investigate the cause immediately (within 24 hr), take preventive measures to preclude its recurrence, and keep a record of the accident for evaluative purposes. An accident investigation report (figure 11–5 shows an example) should be completed.

Make sure everyone understands that the purpose of the report is to prevent recurrence, not to pass blame. Effective accident investigation leads to the identification of accident causes and, along with the analysis of other accident records, reveals ways to prevent recurrence. The principal ways of preventing accidents are to improve the physical conditions creating the hazard, to improve job procedures, to use additional or better personal protective equipment, to give employees additional training, or to reassign

Figure 11–5. Sample accident investigation report

Name of injured:

Date of injury:

Part(s) of body injured:

Nature of injury:

Name(s) of machinery involved:

How did the employee describe the accident?

Did a witness describe the accident the same way as the injured employee?

How do the descriptions differ?

What unsafe condition permitted the accident to occur?

Was equipment operating properly?

What unsafe act contributed to the accident?

Were standard procedures being followed at time of injury?

Was any commonly accepted procedure violated?

What kind of training in this work did the employee have?

Did the employee understand how to do this work properly? If not, why not?

If the cause of the accident is not clear from the above responses, state the cause:

Did the injured employee give ideas to prevent this type of accident from happening again?

What immediate steps were taken to prevent recurrence of the accident?

What permanent steps were taken to prevent recurrence?

Date preventive action was taken:

Investigated by: ______________________________ Date: ______________________________

Reviewed by: ______________________________ Date: ______________________________

employees. Accident investigations and job hazard analysis should involve employee input. Such input can help determine the most practical and effective actions for preventing recurrence.

Nearly all accidents are caused by unsafe work conditions, unsafe employee acts, or a combination of these. The following are lists of unsafe conditions and acts that commonly cause accidents:

Unsafe conditions:

1. Improperly guarded equipment or materials
2. Defective equipment or materials
3. Hazardous arrangements, storage of materials, or procedures
4. Improper lighting
5. Improper ventilation
6. Improper dress
7. Nonfunctional or insufficient protective equipment
8. Lack of knowledge, skill, or training

Unsafe acts:

1. Operating equipment without permission
2. Failing to secure equipment or warn others of dangerous conditions
3. Performing tasks at unsafe speeds
4. Making safety devices inoperative
5. Using unsafe equipment, hands instead of equipment, or equipment unsafely
6. Loading, unloading, placing, mixing, or combining materials in an unsafe manner
7. Having an unsafe position or posture
8. Working on moving equipment
9. Failing to wear safe clothing or other personal protective devices
10. Distracting, teasing, startling, or abusing people; quarreling; throwing materials; practical joking.

References

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Noise in Cotton Gins

W.S. Anthony and J. Weldon Laird

Effects of Noise on Employees

Noise is commonly defined as unwanted sound—engineers classify it as wasted energy. Sounds may be classified as noise by one individual and as music by another. When an individual classifies sound as noise, that person is making a psychological evaluation. All loud sounds, including loud music, may be detrimental to hearing even though some may be pleasing to the individual.

Extreme caution must be used when employees are exposed to prolonged, intense sound. Exposure to such noise may adversely affect their overall efficiency, safety, and hearing ability. People exposed to intense noise, whether agricultural, industrial, recreational, community, or social, can experience stress-related disorders and suffer temporary or permanent threshold shifts in hearing ability.

The adverse effects of loud noise on hearing are not very noticeable initially—there is no warning that harm is being done. Sound levels that seem very loud at first exposure may soon become tolerable (the warning response disappears) because of these effects. Only later does a person realize that he or she can no longer comprehend speech nor hear some of the small sounds that make up our sound environment. Unfortunately, at that point the hearing loss may be permanent.

Exposure time is crucial in determining whether a decrease in hearing threshold will be temporary or permanent. Temporary shifts in threshold result from exposure to noise for a relatively short time. When exposure to the noise ceases, the hearing threshold returns to normal after a length of time. A permanent threshold shift may occur if the person is exposed to noise day after day for many months or years. The amount of threshold shift that a person experiences depends on the properties of the noise, the pattern and duration of the exposure, and the individual.

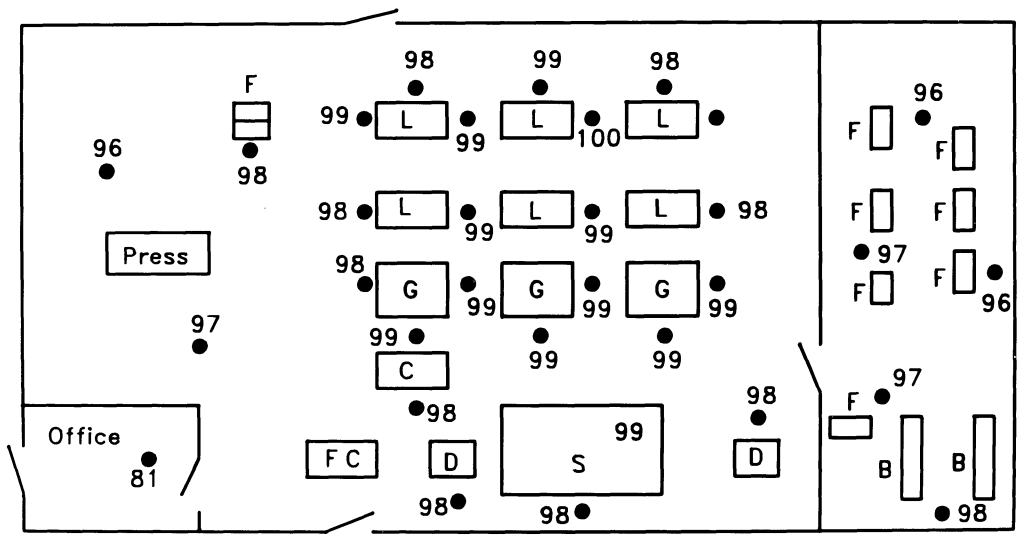
Sound levels of 65–80 dBA (decibels on the A-weighting scale) are annoying but have no demonstrated effect beyond inducing stress or interfering with speech communication. Noise levels of 85 dBA and above have been shown to cause hearing impairment after prolonged exposure (Cooper 1974). Noise levels within a cotton gin typically vary from 95–98 dBA (fig. 11–6). Gin noises are mostly in the frequency range of 31.5–250 cycles/sec, but many are also in the range of 500–2,000 cycles/sec, which is most damaging to the human ear.

Measuring Noise Levels

Sound levels are usually expressed as A-weighted sound levels, octave-band sound-pressure levels, or perhaps sound power levels in specific communication ranges. The A-weighted scale is used to measure the frequencies that

Figure 11–6. Noise levels (in dBA) in a typical cotton gin

B = Burner and fan
C = Control console
F = Centrifugal fan
D = Dryer
FC = Feed control
G = Gin stand
L = Lint cleaner
S = Seed cotton cleaners



the human ear can detect. For noise control purposes, octave-band or one-third octave-band data are used to relate total noise level with specific noise frequencies of machine components. This process is great for pinpointing specific noise sources so that feasible engineering solutions can be determined.

When multiple noise sources are present, it is important to remember that sound is additive on a logarithmic basis. The effect of additional sound sources within an enclosed space, such as a gin building, can be estimated if the sound-pressure level of each sound is known. A simple method can be used to estimate the increase in sound level that results from adding sound sources. This method can also be used to estimate the effects of changes in machinery (noise sources) in a room.

Here is an example of how the method works. To determine the approximate sound level from individual sound sources of 80, 85, 90, 90, and 93 dBA, a ginner must do the following:

1. Rank the sound-level values from lowest to highest.

2. Determine the difference between the lowest two values (80, 85). From the difference (5), determine the amount that must then be added to the higher sound level (85) of these two values. The amount to be added is shown in the box to the left: Since a difference of 5 exists, add 1 dBA to 85, giving a sum of 86.

Sound level difference (dBA)	Amount to be added (dBA)
0 to 1	3
2 to 3	2
4 to 10	1
11 or more	0

3. Pair the sum (86) with the next highest-ranked sound value (90), and determine the difference between these two values (4). Then determine the amount to be added to the higher of the two values (as in step 2)—90 + 1 = 91. Repeat steps two and three to determine how much to add to each of the remaining ranked sound levels. For example, 91 should be paired with 90 (difference of 1, so add 3 to 91, giving 94). Once the calculations are done, the overall sum is 97, the estimated combined sound level. The method can also be used to estimate the effects of changes in machinery (noise sources) in a room.

Government Regulation

Government regulation of noise levels in the work environment began with adoption of the Walsh-Healey Public Contracts Act, May 1969; the Occupational Safety and Health Act of 1970; and the Noise Control Act of 1972. Occupational Safety and Health Administration (OSHA) standards for general industry are two-staged. Hearing conservation measures are mandatory at 85 dBA, and feasible engineering or administrative noise controls are required when noise levels reach 90 dBA for an 8-hr day. Cotton gins, however, are agricultural operations and are not covered under specific OSHA noise standards. But gin noise is a hazard that should be treated with feasible engineering controls, administrative controls, and personal protection devices, such as earplugs or earmuffs. The OSHA general industry standards (part 1910) represent possible guidelines for noise control efforts in gins.

Noise Reduction

Gin noise can be reduced in three simple steps (Harris 1979).

1. Evaluate the noise level of each source. This process includes determining the frequency of the sound of the components of the gin machinery. These components might be rotating fan blades, individual drive motors, gears, pulleys, etc.

2. Identify the path that the noise takes between the source and the human ear. Many times the path amplifies or reduces the noise before it reaches the ear. Distance; atmospheric conditions; wall, floor, and ceiling surfaces; and workplace volume are some factors that modify noise as it travels between the source and the ear.

3. Modify the source or path of the noise or both. Noisy machines can be replaced, altered, or isolated. Various devices can be used to shield or absorb noise before it reaches employees.

Reduction of noise levels in gins is usually for the benefit of employees. In some cases, however, reduction may be for the benefit of neighbors or it may be to comply with a company- or government-imposed noise restriction. Within gin plants, it is very important to ensure that gin noise is restricted enough to permit some communication among employees.

Most noise reduction efforts are directed toward those frequency bands that interfere with the human ear. Cotton ginning systems contain numerous types of machinery—each a source of noise. The most common sources of noise are vane-axial fans, centrifugal fans, gin stands, lint cleaners, seed cotton cleaners, hydraulic pumps, and motors (Anthony 1974). Four dominant noise sources can be identified in gins: doffing brush noise in the 500–1,000 cycles/sec band, high-frequency noise of air and cotton in the piping, low-frequency noise due to rotating machinery parts, and fan noise in the 125 cycles/sec band (Laird and Baker 1982). Straight-bladed centrifugal fans and doffing brushes in gin stands and lint cleaners are usually the loudest sources (Anthony 1977). Each source of noise contributes to the overall sound level.

Cotton is conveyed from point-to-point in sheet metal piping. The passage of seed cotton through piping contributes significantly to the overall noise level in a ginning system, especially at elbows. Sounds are created, amplified, and reflected by the many metal machines, pipes, and ducts.

Selection of an appropriate noise control treatment to limit the generation, transmission, and reception of noise by various sources depends on the frequency and level of the noise as well as economics. Noise abatement treatments should meet the design goal at the lowest possible cost and must not interfere with the operation, maintenance, or safety of the equipment. The effective cost of the noise reduction techniques must include the adverse effects upon the employees and the reductions in efficiency of the machine.

The following noise control techniques should be considered in reducing the amount of noise that employees will be exposed to:

1. Modify the noise sources to make them quieter, or replace them with quieter machines. If necessary, change the structural material of sources.

2. Modify the noise path by using acoustic barriers, acoustic enclosures, or operating booths.

3. Muffle noise by using dampening (viscoelastic) materials, vibration isolators, flexible connectors, mufflers, or lined air ducts.

4. Balance rotating components.

5. Use administrative controls. Limit the exposure time of employees; station them away from noisy areas. Have employees wear personal protective equipment (earmuffs and earplugs).

Some of these techniques are not discussed here. They are listed here simply to acquaint the readers with them.

Barriers are placed directly in the path between a noise source and an employee to reduce the sound level at the ear. The amount of reduction is a function of the spectrum of the machinery noise, the size of the barrier, and the closeness and geometry of other reflecting obstacles or surfaces. The reflective barrier does not absorb sound energy—it only redistributes it. Barriers are most effective at short ranges. The effectiveness of barriers in reducing the A-weighted sound level decreases by 5–8 dBA with each 20–40 ft increase in distance between source and barrier or barrier and employee. A solid barrier should provide direct sound interception and should extend beyond the direct sound path by at least 7 ft in horizontal and vertical directions.

Enclosures may be complete or partial. Complete enclosures that are not insulated, partially insulated, or fully insulated should have a respective sound transmission loss of at least 20, 15, and 10 dBA greater than the desired attenuation. Their effectiveness is enhanced by high-sound-transmission-loss material, acoustic insulation, and acoustically treated openings (sound traps). When enclosures are used, noise reductions of 20–30 dBA are common. The effectiveness of complete enclosures is easily compromised by a small hole or flanking path.

Partial enclosures can reduce noise levels 6–10 dBA. Acoustic absorptive materials lining the enclosures are highly important in reducing noise effectively. The acoustic lining should be 1.5–3 inches thick for high-frequency noise and 4–8 inches thick for low-frequency noise.

Machine enclosures sometimes interfere with access to machines but are a viable method of noise control. A complete enclosure around the machine may be required, or a partial enclosure may suffice. Partial or complete enclosures should be constructed in such a manner as to restrain the noise inside the enclosure and yet allow ready access to the machine by the operator when necessary.

An analysis of a typical noise source may offer opportunities for reducing gin noise. A wide variety of machines are usually available to perform the same function, but these machines may produce widely different noise levels. Substituting quieter machines for noisy machines may reduce the noise to acceptable levels. Certain components within a machine may be replaced by components that are less noisy yet still effective.

Administrative controls, such as requiring employees to wear earplugs and/or earmuffs, are feasible. Earplugs are worn either within the ear canal or against the external ear canal. They may be disposable or nondisposable and are made of materials such as moldable plastic, plastic foam, silicone rubber, clay, or glass wool. Earmuffs consist of two earcups mounted on a headband. Each earcup should fit snugly against the side of the head and completely enclose the external ear.

Maximum protection is obtained when earplugs and earmuffs are worn at the same time. Noise reduction can vary considerably with type and fit of various ear protectors and with sound frequency. The hearing protection (number of decibels that noise is reduced by ear protection devices) provided by typical, efficient earplugs or earmuffs varies from 5 dB at 20 hertz to 40 dB at 8,000 hertz. Proper fit and comfort are especially important in getting employees to consistently use ear protection. Employees will probably refuse to wear ear protectors that are uncomfortable. For gin use, ear protection devices should reduce the noise level at least 10 dBA.

Although administrative controls and ear protection devices can be effective in gins, these means of noise control are typically less reliable than engineering solutions. Improvements in engineering can result in a cotton gin that is quieter, safer, more efficient, and less costly to operate. Researchers have developed doffing brushes that have a solid brush surface (fig. 11–7) to eliminate much of the noise from conventional doffing brushes (Anthony 1977, Anthony and McCaskill 1978, Laird and Anderson 1977). These brushes are economical and offer extended service due to their long (6-inch) filament length as compared to the 1-inch length of conventional brushes. Noise reductions of 10–20 dBA are common, and brush noise is virtually eliminated.

The inlet area of fans and the space between tandem lint cleaners are extremely noisy unless noise abatement techniques have been implemented; employees should avoid these areas. Vane-axial fans can be replaced with airfoil-type centrifugal fans or oversized standard centrifugal fans to considerably reduce noise levels and horsepower requirements. Noise levels of centrifugal fans can be reduced by using larger, lower-speed fans and locating them in separate fan rooms that can be insulated (Anthony 1979). High-efficiency fans can be used to deliver the same air volume at slower speeds and with less noise. In clean-air applications, straight-bladed centrifugal fans can be replaced with multiblade or airfoil-type fans. Fan intakes can be extended several feet into the air to lower the noise at ear level and to provide heat recovery and fewer problems with pickup of lint fly. Mufflers composed of double-walled insulated pipe in which the inner pipe is made of perforated or expanded metal are also effective.

Seed cotton conveyance noise can be dramatically reduced by placing viscoelastic dampening material outside the impact areas in pipes (fig. 11–8), valves, machines, and transitions (Anthony 1981a, 1983). Fiberglass and high-efficiency foams can also be used for this purpose (Anthony 1981b).

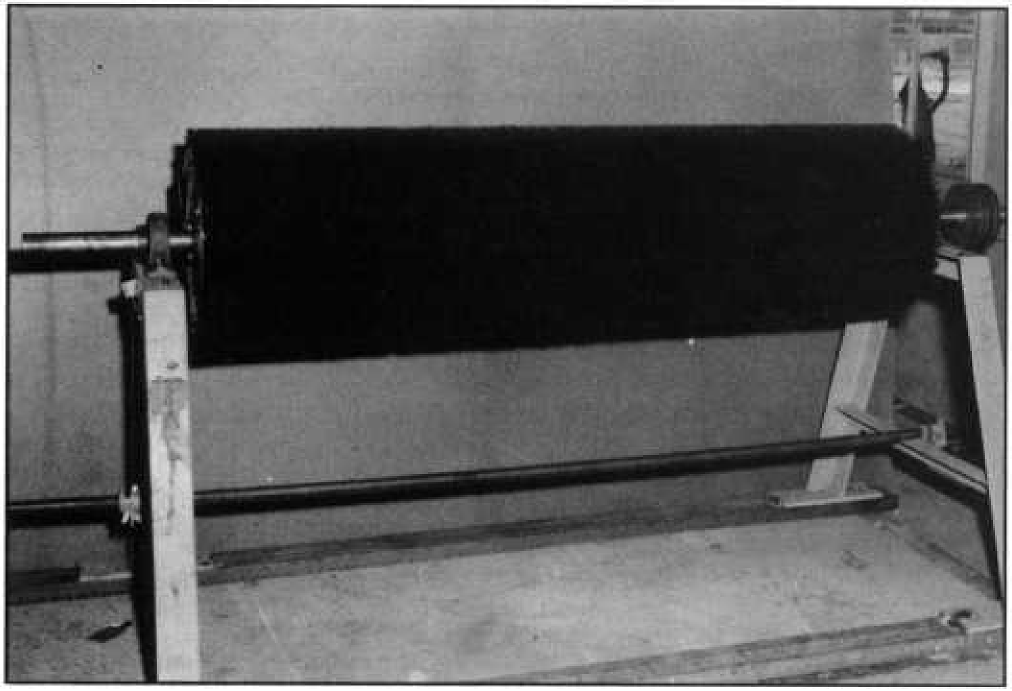


Figure 11–7. Low-noise, spiral-wound brush cylinder for lint cleaners, gin stands, and other gin machinery

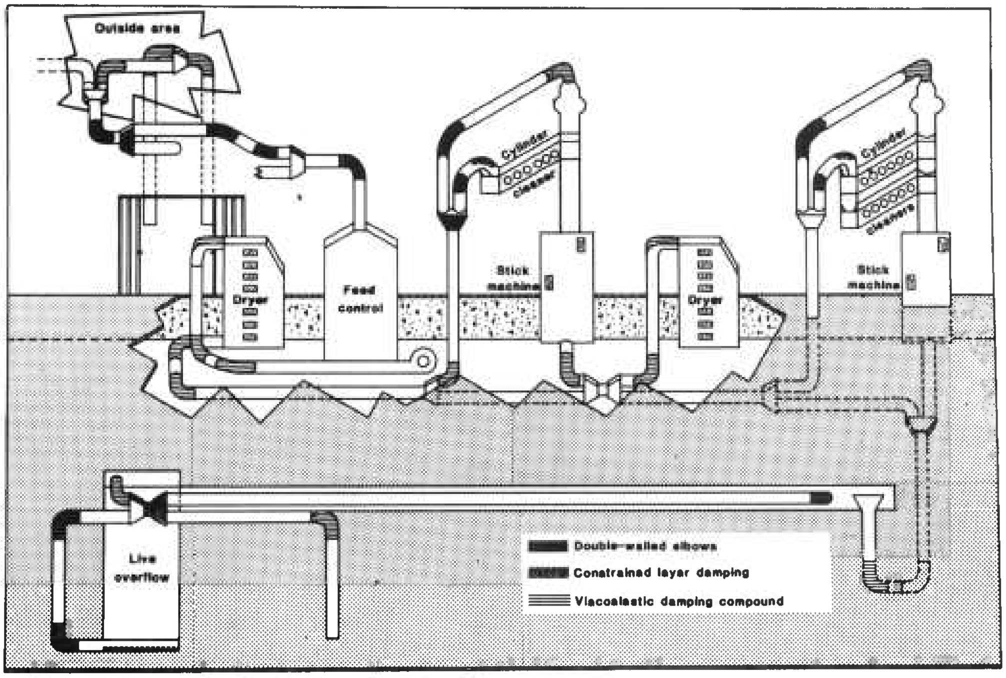


Figure 11–8. Impact points where noise from cotton being conveyed can be reduced by adding viscoelastic material within the pipe

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SECTION 12—THE CLASSIFICATION OF COTTON

Jesse F. Moore

Historically, the U.S. Department of Agriculture (USDA) has classed (graded) about 97 percent of the U.S. cotton production for growers each year. Since 1981 growers have paid for the service. The classification system has undergone significant change, moving from heavy reliance on the human senses to the utilization of precision instruments that analyze more quality factors with greater accuracy. Currently, some USDA quality determinations are still made by classers, but the majority are determined by high-volume instruments, commonly referred to as HVI.

Classer Determinations—Upland Cotton

Color Grade

There are 25 color grades for American upland cotton plus five categories for below-grade color. Fifteen of these grades are represented in physical form by samples prepared and maintained by USDA. The remaining standards for color are descriptive. The range of each color grade for which there is a physical standard is represented by six samples placed adjacent to each other in a standards box. For practical considerations, the color and leaf grade standards are contained in the same box. For instance, the standards box containing the Strict Low Middling color grade also contains the size and amount of leaf that would be described as leaf grade 4.

Each descriptive standard provides a description for cotton that lies above, below, or between certain physical standards. Copies of the physical standards are prepared primarily for USDA's own use but are also sold to foreign and U.S. customers.

Color grades fall into five color groups as follows: White, Light Spotted, Spotted, Tinged, and Yellow Stained (table 12–1). The color is affected to a great extent by weather and length of exposure to weather conditions after the bolls open. It may also be affected by varietal characteristics and by harvesting and ginning practices. When upland cotton opens normally, it has a bright, white color. Abnormal color indicates a deterioration in quality. Continued exposure to weather and the action of micro-organisms can cause the white cotton to lose its brightness and become darker in color.

When plant growth is stopped prematurely by frost, drought, or other weather conditions, the cotton may have a yellow color that varies in intensity. Cotton may also become discolored or spotted by insects or fungi.

Leaf Grade

Leaf grade describes the leaf content of the cotton. There are seven leaf grades (numbered 1 through 7), and all are represented by physical standards. In addition, there is a "below grade," which is a discriptive standard.

In the spinning industry leaf material is viewed as waste and adds an additional cost factor associated with its removal. Leaf content is affected by the different types of harvesting methods and harvesting conditions. The amount of leaf material remaining in the lint after ginning depends on the amount present in the seed cotton before ginning and on the type and the amount of cleaning and drying equipment used during ginning. Even with the most

Table 12–1.
Color grades of upland cotton (effective 1993)

Description	White	Light Spotted	Spotted	Tinged	Yellow Stained
Good Middling	[1]11	12	13	—	—
Strict Middling	[1]21	22	[1]23	24	25
Middling	[1]31	32	[1]33	[1]34	35
Strict Low Middling	[1]41	42	[1]43	[1]44	—
Low Middling	[1]51	52	[1]53	[1]54	—
Strict Good Ordinary	[1]61	62	[1]63	—	
Good Ordinary	[1]71	—	—	—	—
Below Grade	81	82	83	84	85

[1]Physical Standards. All others are descriptive.

careful harvesting and ginning methods, a small amount of leaf material will remain in the cotton lint. Generally, there is less leaf material in ginned cotton now than in past years, primarily because of improvements in harvesting and ginning methods.

Preparation
Preparation is a term that refers to the degree of roughness or smoothness of the ginned lint cotton. As a general rule, smooth cotton has less spinning waste and produces a smoother and more uniform yarn than rough cotton. Various methods of harvesting, handling, and ginning can produce readily apparent differences in preparation. Because of improvements in equipment and practices, abnormal preparation now occurs in less than one-half of one percent of the crop during harvesting and ginning. When preparation for a crop of cotton is abnormal, this abnormality is noted in the classification remarks for that crop of cotton.

Extraneous Matter
In a cotton sample extraneous matter is any substance that is not cotton fiber or leaf material and that is not discernible in the official cotton standards. Examples of extraneous matter are bark, grass, spindle twists, seedcoat fragments, dust, and oil. When such extraneous matter is present, a notation will be recorded in the classification data for that cotton. The classer determines whether the amount of extraneous matter present in the sample is excessive enough to be noted.

HVI Determinations—Upland Cotton

Fiber Length
Fiber length is measured by passing a small tuft of parallel fibers through a sensing point of the HVI system. The tuft is formed by grasping the fibers with a clamp and paralleling them by combing and brushing. Reported

length is the average or mean length of the longest one-half of the fibers (upper-half mean length). Results are reported to the nearest one-hundredth of an inch. For example, 1.06 equals approximately 1-1/16 inches. Length is also reported in thirty-seconds of an inch.

Fiber length is a varietal characteristic. The length decreases when temperatures during the early stages of fiber development exceed the optimum for the variety or when moisture is limited.

Length Uniformity

Length uniformity is the ratio of the average or mean length of the fibers to their upper-half mean length and is expressed as a percentage. The same tuft of fiber used for length measurement is used to determine length uniformity. If all fibers in a sample were the same length, the length-uniformity index would be 100. The following gives a general indication of what length uniformity means:

Description of uniformity	HVI length uniformity
Very High	Above 85
High	83–85
Intermediate	80–82
Low	77–79
Very Low	Below 77

The presence of short fibers, or those fibers less than one-half inch in length, adversely affects the utility and quality of cotton. Short fibers tend to aggregate during drafting (grasping and pulling with increasing speed) and cause thick places in yarn. Yarns with thick spots are not uniform and cannot be used in high-quality products. Short fibers do not add strength to ring-spun yarns, and the thick places are frequently points of weakness in yarns. The aggregates of short fibers cause disruptions in processing known as ends-down.

When fibers are removed from the seed in ginning, some fibers break at a point other than near the seedcoat and must be removed in two pieces. Lint cleaners can also break fibers. Machines that are operated or set improperly contribute to fiber breakage, shorter staple length, and lower length uniformity. Immature fibers have less resistance to breakage than mature fibers. Low-micronaire cotton has comparatively lower length uniformity than high-micronaire cotton. Fiber strength also affects resistance to breakage. Stronger cotton has higher length uniformity than weaker cottons.

Fiber Strength

Fiber strength is determined by the HVI system on the same tuft of fiber used for the length measurement. The jaws of the breaking clamps are spaced one-eighth inch apart.

Results are reported in grams per tex. A tex is equal to the weight in grams of 1,000 m of fiber. The strength reported is the force in grams required to break a one-tex bundle of fibers. The information on the left gives a general description of fibers of different strengths.

Description	HVI strength (g/tex)
Very strong	30 and above
Strong	27–29
Intermediate	24–26
Weak	21–23
Very weak	20 and below

Fiber strength is a varietal characteristic and is less influenced by adverse growing conditions than are length and micronaire.

Micronaire

The term "micronaire" refers to an airflow measurement that indicates fiber fineness and maturity. Micronaire is determined by passing air compressed to a standard volume through a cotton specimen of standard weight and standard volume. The volume of airflow through the specimen is expressed as the micronaire, which may be referred to as the "mike reading" or simply "mike." Optimum micronaire is dependent upon many things, including the variety of the cotton and the relative importance of strength and appearance in a yarn or fabric. Different varieties vary in micronaire at full maturity.

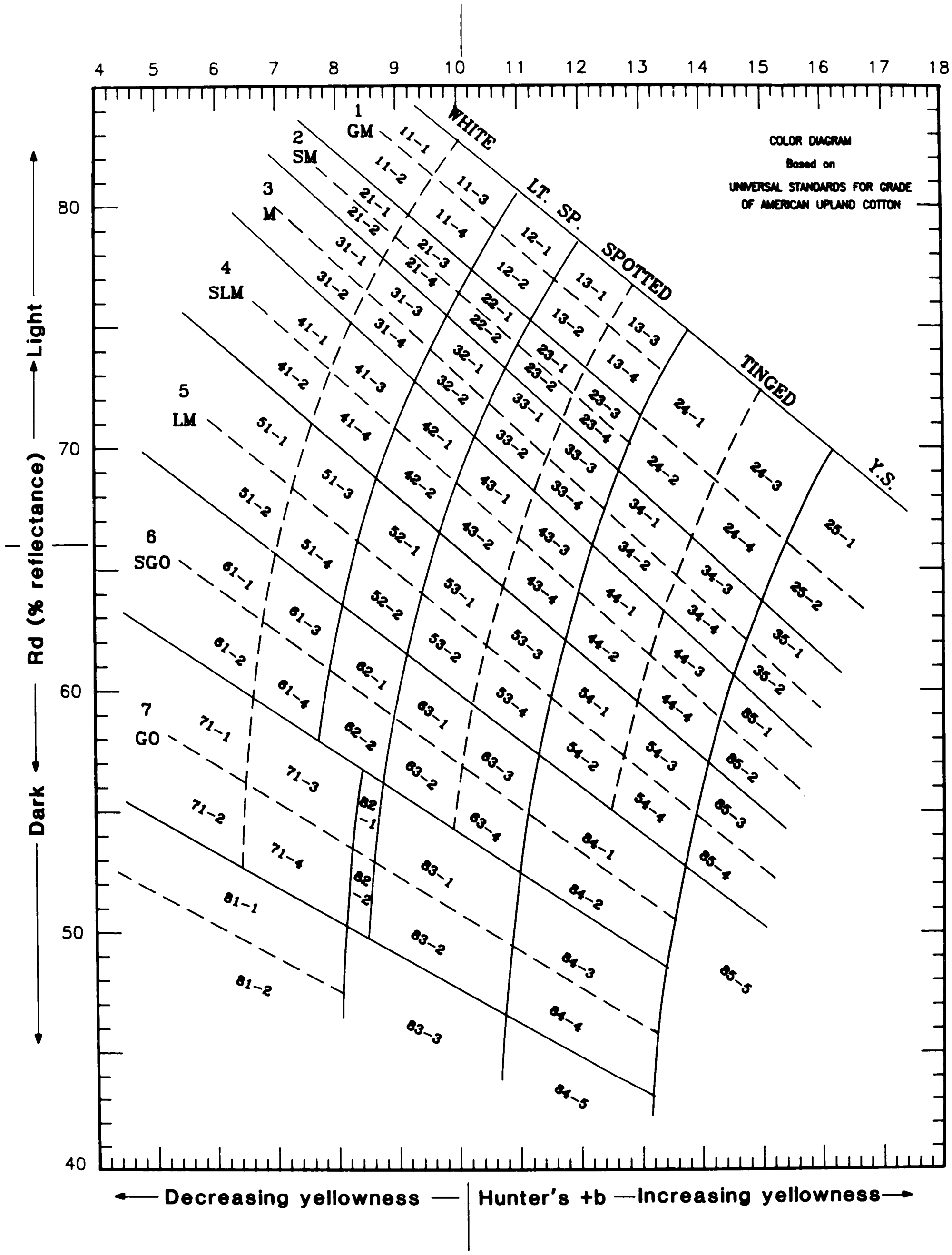
Some fibers are extremely fine simply because they are immature. These fibers cause dyeing irregularities, increase manufacturing waste during picking and carding, and lower product appearance. A mike reading below the optimum range may indicate immaturity; one above the optimum range may indicate that the fiber is too coarse for manufacturing many high-quality products.

Fiber fineness is a varietal characteristic but is also affected by growing conditions in the later stages of fiber development. Favorable growing conditions result in fully mature fibers and high mike readings. Unfavorable conditions, such as lack of moisture, early freeze, or any other conditions that interrupt plant processes, will result in immature fibers and low mike readings.

Color

Presently, the USDA classification system includes a determination of color by the classer and also by HVI. The HVI color determinations are in terms of grayness (measured in Rd) and yellowness (measured in +b). Grayness (or percent reflectance) indicates the lightness or darkness of the sample. Cotton Rd values are usually within the 48 to 82 range. Yellowness indicates the amount of yellow coloration in the sample and is usually within the 5.0 to 17.0 range. Normally, opened cotton will have an Rd of 70 or higher and a +b of 9.0 or lower. The various combinations of grayness and yellowness can be converted into color values by plotting the Rd and +b values on an official color chart (fig. 12–1).

Figure 12–1. Official cotton color chart for American upland cotton. Source: USDA, Agricultural Marketing Service, Cotton Division



Trash

In addition to the classer's leaf grade, USDA provides an instrument-read determination of the trash content in the sample. The trash content measured by the HVI system is determined by scanning the sample surface and recording the particles present. Results are reported as the percentage of the sample surface covered by nonlint particles. The maximum is less than 5.0 percent. The information on the left lists the leaf grades and average trashmeter readings of upland cotton.

Classers' leaf grade	Trashmeter reading (percent)
1	0.08
2	0.12
3	0.18
4	0.34
5	0.55
6	0.86
7	1.56

American Pima Grades

American pima grade standards are also represented in physical form. There are six American pima grades, numbered 1 through 6. American pima and upland grade standards differ. American pima cotton has a deeper yellow color than upland cotton. The leaf content of American pima standards is unique to this cotton and does not match that of upland standards. The preparation is very different from the preparation for upland standards, since American pima cotton is normally ginned on roller gins and is more stringy and lumpy. Upland cotton is usually cleaned with saw-type lint cleaners that produce a smooth, blended, combed sample. Roller ginned cotton is usually cleaned with an air or cylinder-type cleaner and is rough in appearance.

SECTION 13—TEXTILE INDUSTRY NEEDS

Frank X. Werber and Everett E. Backe

Introduction

Why should the ginner know something about the needs of the textile industry? Like anyone else in a business, the ginner has a goal to satisfy the customer. The immediate customer is the cotton farmer, but the farmer's customer is the textile mill, and the ginner must satisfy both. Yet few ginners have the opportunity to be close enough to the mill to understand why textile people want certain fiber properties and how these relate to performance.

The system of grading cotton is designed to relate grading factors as closely as possible to fiber properties that are important to the textile mill and important in the end product. The grading system is changing; the new system, called the "high-volume instrument (HVI) system," will reward the grower and ginner for producing cotton that meets textile requirements.

What kind of cotton does the textile manufacturer want? For most end uses the manufacturer wants a fiber that runs as efficiently as possible on textile machines and that costs as little as possible. The end product yarn or fabric must be accepted by customers as first quality.

The U.S. cotton producers typically harvest about 14–17 million bales of upland cotton per year. Over half of this cotton is consumed annually in U.S. textile mills; most of the balance is exported. The two major markets for the cotton are fabrics for apparel and home furnishings.

Most textile manufacturers buy cotton having a level of quality that is ideally suited for their end use. All cottons cannot be used for all end products. Generally, the lighter the weight of the product being manufactured, the higher the cotton quality required. For example, the fiber requirements for sheetings and fine shirtings are much more stringent than the requirements for heavier fabrics like denim. Sheeting and shirting yarns are generally much finer in weight per unit length. Because sheeting and shirting yarns are finer, they require cleaner, longer, finer, and stronger fibers to facilitate efficient production through yarn manufacturing and weaving and to produce a quality end product. In certain instances, cotton of lowest quality can be blended with manmade fibers. The manmade fibers generally aid in carrying the shorter, more variable cotton through production.

Important Fiber Properties

In processing and in determining the end use of cotton, the following properties are critical:

1. **Fiber strength.** The strength of cotton fibers is measured by the HVI system and reported in grams of force per tex. A tex is equal to the weight in grams of 1,000 m of fiber. Strength ranges from 20–32 g/tex for upland cottons and 35–45 g/tex for pima cottons.

2. **Fiber length**. This is expressed as upper-half mean length (the average length of the longest one-half of the fibers) or as the 2.5-percent span length. Fiber length of commercial varieties of upland cottons range from 7/8 inch to 1-1/4 inches (upper-half mean length).

3. **Micronaire**. Micronaire is an indirect measure of fiber diameter (fineness). Within a given family of cotton varieties, micronaire also is a good measure of the thickness of the so-called secondary cell wall, which is a measure of fiber maturity. Maturity is very much related to performance in dyeing for certain end uses.

4. **Grade—trash content and color**. Separate grades are determined for trash content and color by a cotton classer with the assistance of HVI instruments. The classer compares a sample against a series of cotton standards. Trash content has a direct bearing on how well the cotton processes in the textile mill. The spinner is concerned with the amount and size of trash. The very large particles are easy to remove but small particles, which are commonly called pepper trash, are very difficult to remove. Pepper trash causes unevenness and imperfections in the yarn. Many of the small trash particles are actually seedcoat fragments. Color is an indicator of field weathering.

5. **Short-fiber content**. The percentage of fibers shorter than one-half inch has a major effect on how the cotton processes, on yarn strength, on the number of imperfections found in the yarn, and on the evenness of the yarn. These four properties are most important in governing the performance of yarns in weaving or knitting and in determining the quality of the final fabric.

6. **Maturity**. Textile manufacturers desire mature cotton because of its dyeability in the finished fabric. Clumps of immature fibers, which are commonly called dead fibers, pose particular problems when they are dyed deep colors in certain cotton knits, corduroys, and dress goods—the dead fibers show up as small, white specks that are clearly visible in the fabric. The ginner has very little control over these dead fibers. Variety, environment, and crop management are more important in eliminating these fibers than ginning methods.

7. **Stickiness**. Stickiness in cotton is often called honeydew. In extreme cases, this condition can shut down a yarn mill. The fiber can be so sticky that cards, drawframes, roving frames, and spinning frames will clog up and cause repeated breaks in the flow of the cotton. Such breaks are known as ends-down. The principal cause of stickiness is invasion of the cotton by whiteflies or aphids in the last months before harvest; these insects deposit droplets containing mixtures of various tacky sugar compounds on the fiber.

8. **Fiber cohesion**. Simply stated, this is the property that controls the friction between fibers—how they slide past each other in carding,

drawing, or spinning and, in turn, how they adhere to each other and affect yarn strength of the spun yarn. Cotton with very low fiber cohesion is ideal for drawing and spinning because the fibers hold together but slide past each other very readily. Once the cotton is in yarn form, a high fiber cohesion is ideal for maximizing the strength of the yarn and for maximizing the yarn's ability to accommodate very large forces during high-speed weaving and knitting. Fiber cohesion is not currently measured by the HVI system.

Modern Textile Processing Technology

Users of U.S. cotton, whether in the United States, Europe, or the Far East, for the most part run modern, highly automated machinery. Partly to reduce dust levels in the mills and partly to cut labor cost and to improve quality, the cotton textile industry invested heavily in new equipment in the 1980's. In the United States alone, mills annually spend over $2 billion on new machinery; the majority is spent on systems to process cotton and cotton blends into yarns and fabrics.

Opening, Cleaning, and Blending

As shown in figure 13–1, bales of cotton are arranged in line on the floor. The surface fiber is skimmed off with a moving fluffing roller/suction system, and the cotton is then transported by air to an opener (fig. 13–2). There, "fingers" mounted on rotating shafts pull apart the fiber mass and effect partial cleaning. The fiber is then transported through one or more step cleaners for further cleaning. The step cleaner (fig. 13–3) is similar in concept to the inclined cleaner that is used to clean seed cotton in the gin plant. In plants where cotton is blended with polyester fiber on a regular basis, a blender or mixing machine is also included in the sequence. This machine can be bypassed in manufacturing 100-percent-cotton yarn.

Carding

After cleaning, the fiber is transported directly into a carding machine or card (fig. 13–4). Its chief functions are to clean and align the fibers for subsequent yarn-forming steps. In this machine, fibers are partially parallelized, and some small trash, seedcoat fragments, and neps are removed. Fiber is transported through the card's cylinders. The main cylinder has sawtooth cylinder wire wound around the periphery. The fibers are formed into a web across the width of the card. The web is condensed into a 1- to 1-1/2-inch wide ropelike aggregation called sliver. The sliver is collected in cans and then moved to combing or moved directly to drawing if the combing step is to be omitted.

Combing

Fine fabrics, such as percale sheets and most dress shirts and blouses, are made from combed yarns. Such yarns have been processed in a comber (fig. 13–5), a device that combs the cotton and removes short fibers and some residual foreign material such as seedcoat fragments. The process is expensive, since 10–15 percent of the material is removed as "comber noils," which have a low value.

Figure 13–1. "Unifloc" top feeder for cotton bales (courtesy of Rieter Machine Works, Ltd.)

Figure 13–2. Axi Flo-type cotton opener (courtesy of Marzoli, Inc.)

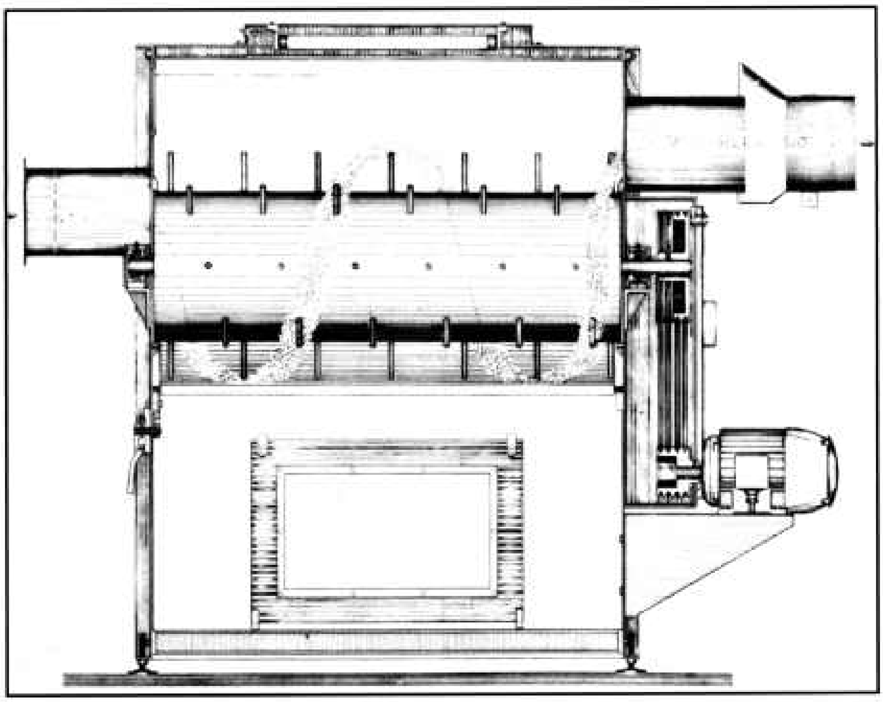


Figure 13–3. Step cleaner (courtesy of Marzoli, Inc.)

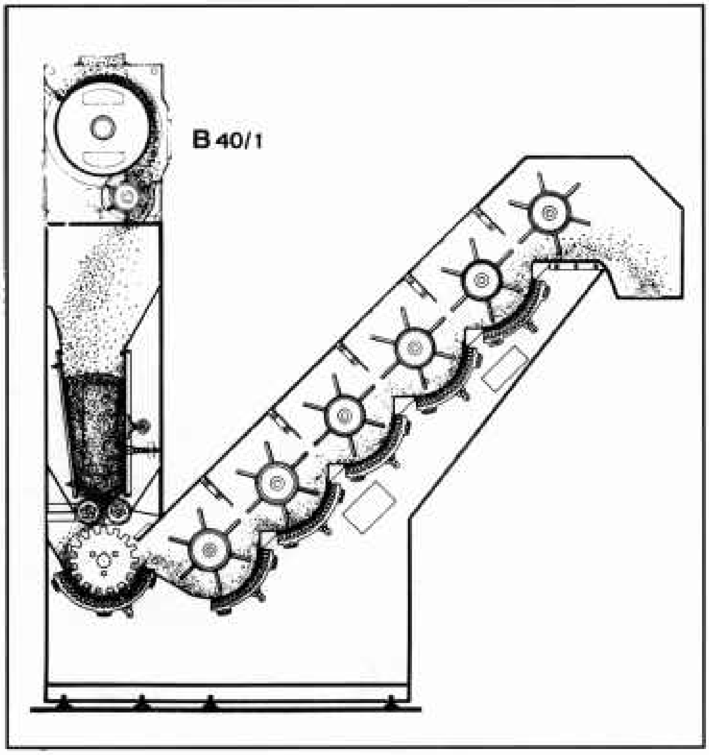
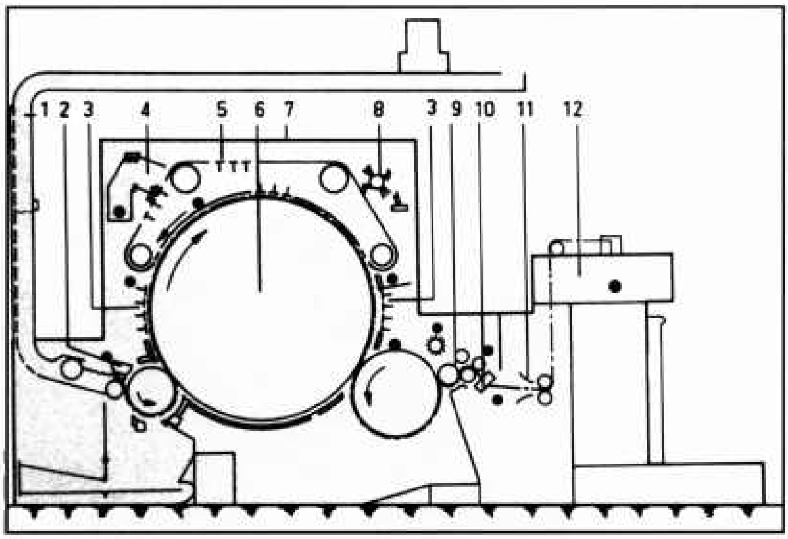


Figure 13–4. Schematic of a high-production C4 card (courtesy of Rieter Machine Works, Ltd.)

1	-	Aerofeed-F or Aerofeed
2	-	Unidirectional feed
3	-	Stationary cardingplates
4	-	Main flats cleaning
5	-	Reverse-running flats
6	-	Cylinder
7	-	Complete casing
8	-	Flats after-cleaning
9,10	-	Web detaching and gathering
11	-	Integrated levelling
12	-	Can coiler C8-600A
•	-	Suction points



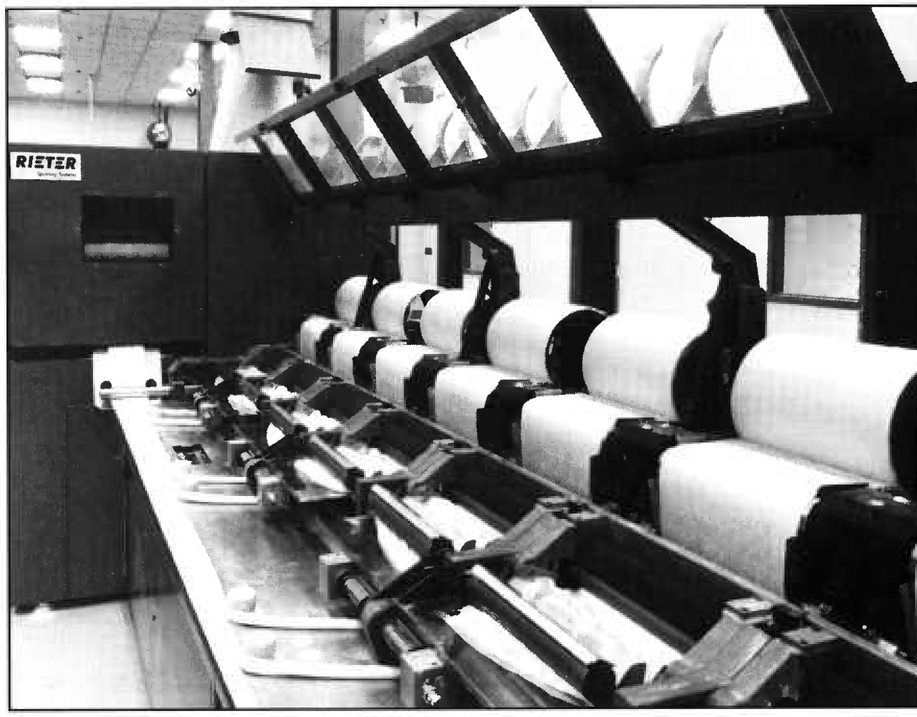


Figure 13–5. Front end of a Rieter E7/6 comber (courtesy of Rieter Machine Works, Ltd.)

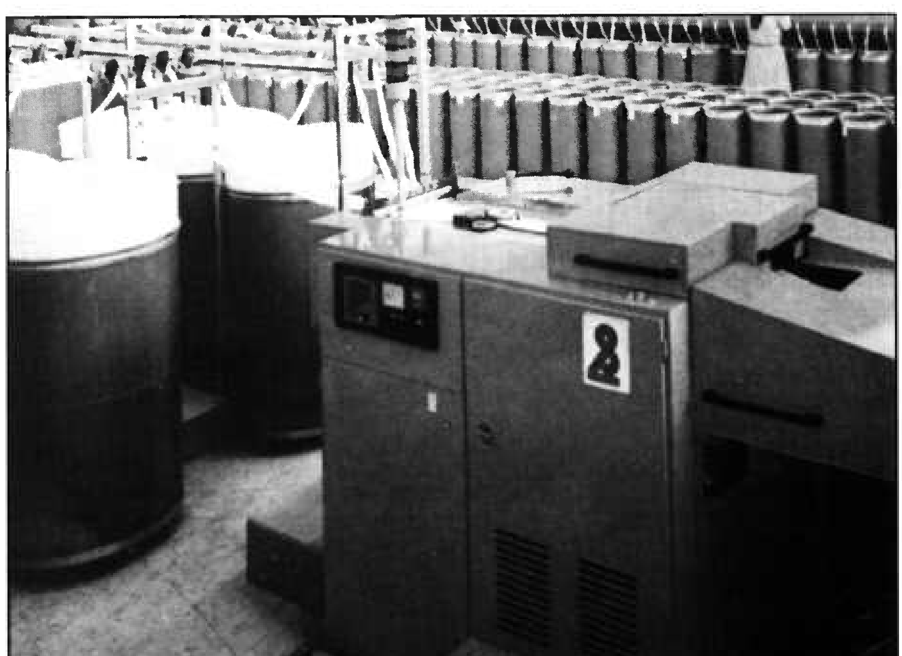


Figure 13–6. Drawframe showing cans of sliver in the creel (courtesy of Rieter Machine Works, Ltd.)

Drawing

This step prepares fibers for ring spinning and further parallelizes and evens out some of the variations in weight per unit length. The variability is reduced by combining a number of slivers together and drafting them down into a single sliver. Figure 13–6 shows a drawframe being fed from different cans.

A can at the front of the machine is used to catch the combined sliver. Generally, one, two, or three successive stages of drawing are used. The number of stages used depends on the spinning system that is used and the yarn characteristics that are desired. For open-end spinning, drawing may be omitted entirely.

Roving

After the sliver has been drawn, it is prepared for ring spinning by more drafting so that the weight of material being fed to the spinning frame does not exceed the capability of the frame. This process is called roving and is performed on sliver regardless of whether it has been carded or combed. In the roving frame, the drawn sliver is fed to a machine that has close to 100 spindles on it for drafting and winding the roving onto a package suitable for ring spinning. Figure 13–7 shows a front view of a roving frame.

Spinning

Two major systems of spinning are now in common use. The traditional method is ring spinning. In this method the roving is further drawn out and twisted by a small, rotating wire traveler on a ring and by a spinning bobbin on which the yarn is collected. Spindle speed (that is, the speed of the traveler on the ring) currently ranges from 8,000–25,000 rpm. Figure 13–8 shows a schematic view of a ring-spinning frame. The most recent, fully automated spinning frames operate at higher speeds than older spinning frames. The actual yarn delivery speed is between 16 and 27 yd/min. Many fiber properties play a substantial part in determining both spinning efficiency and quality of the ring-spun yarn produced. The amount of residual short fibers and the staple length will determine the cotton's spinning potential—that is, the "count," or the fineness of the finest yarn that can be made from the cotton. Residual seedcoat fragments, trash, and other nonfiber particles will cause unevenness in the structure of the yarn and an unacceptably large number of breaks in spinning. Spinning breaks are known as ends-down and reduce production efficiency. The unevenness in yarn is measured by the number of thick and thin places. Eventually, the quality of the woven or knitted fabrics produced is also affected by yarn defects.

The second major spinning method is open-end spinning. It owes its success almost entirely to the cotton fiber, which is ideally suited to the procedure. In this method sliver is fed directly into a rotating opening roll (fig. 13–9); the rotation is as fast as 10,000 rpm. After passing through the fiber tube, centrifugal force causes the fibers to separate and align themselves in the groove of the rotor, which operates at speeds of 80,000 to over 100,000 rpm. The fibers are assembled into a yarn that is continuously pulled out from the back end of the chamber (at speeds as high as 150–200 yd/min) and wound

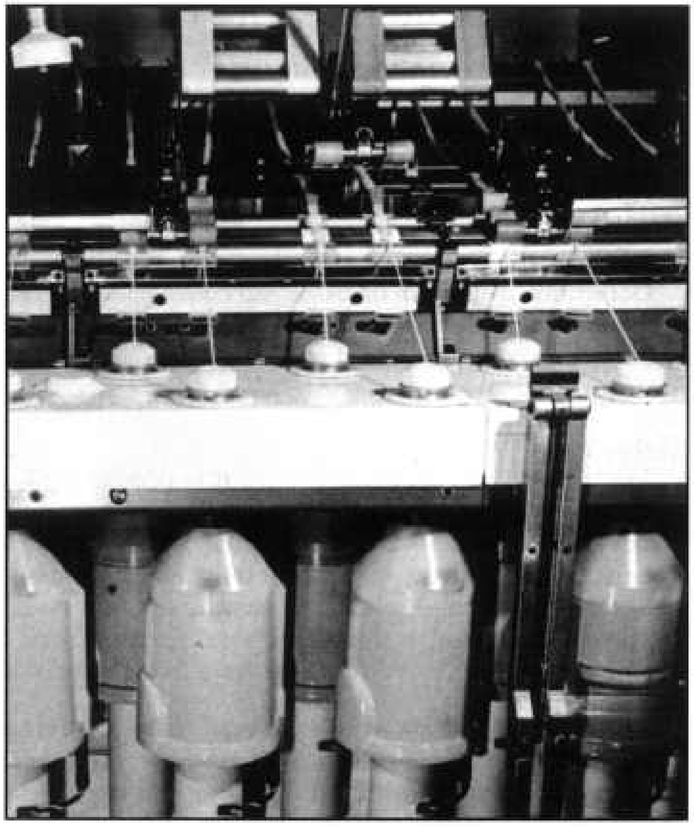


Figure 13–7. Front view of a roving frame (courtesy of Marzoli, Inc.). Note sliver being fed in the back.

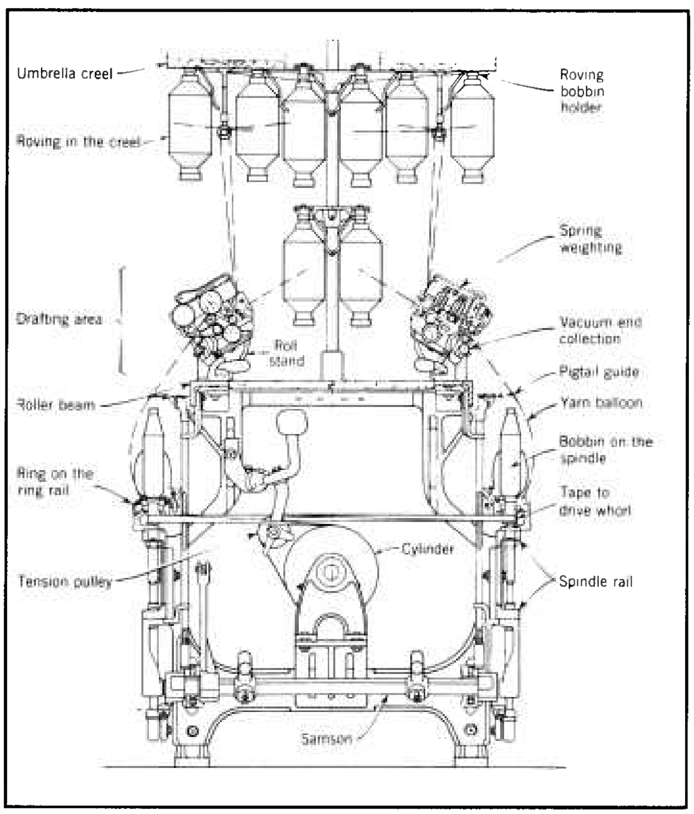
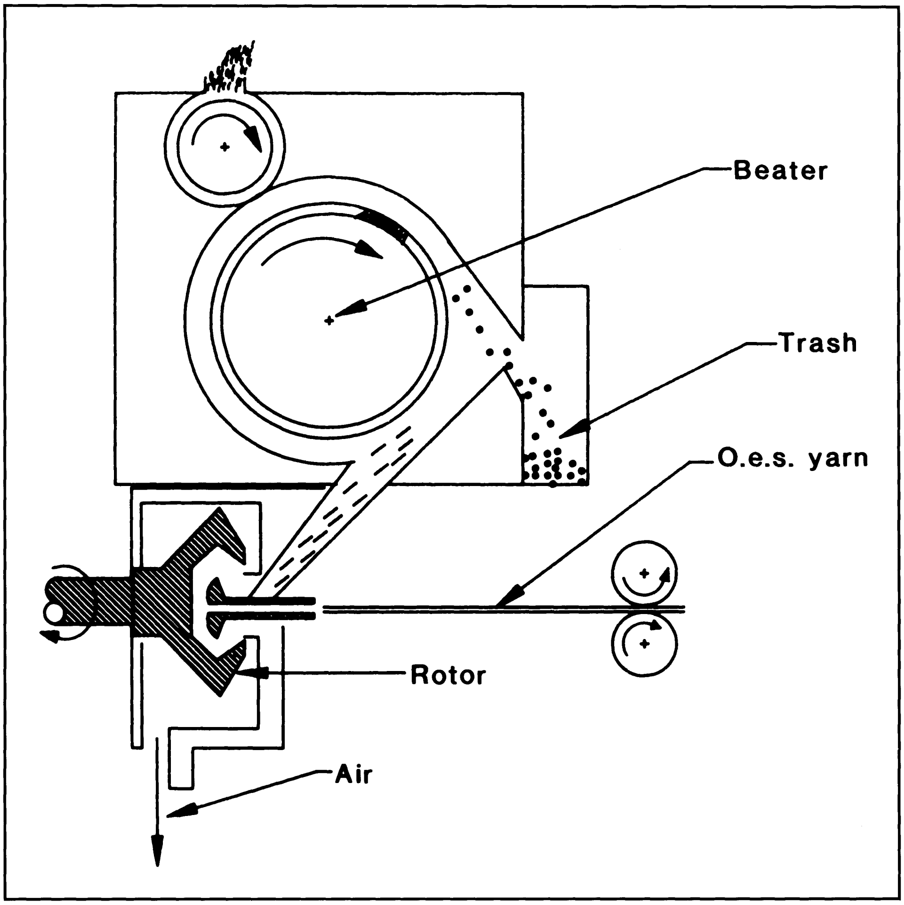


Figure 13–8. Schematic diagram of a ring-spinning frame

Figure 13–9. Schematic diagram showing principle of open-end spinning



on a package. Figure 13–10 shows a front view of an open-end spinning machine. Sliver is fed from the cans at the bottom of the photograph to the enclosed rotor mechanism; spun yarn is wound on the packages at the top. Cleanness of the cotton is particularly important for open-end spinning, since trash and dust particles tend to accumulate in the spinning chamber, causing poor quality and breaks in spinning.

An additional spinning machine, the airjet machine (fig. 13–11), is finding increasing application in the United States. As the name implies, the machine is based on the peripheral action of a system of airjets. Individual high-speed airstreams sling external fibers of a sliver around the rest of the fiber bundle while it is drawn out to the desired yarn diameter. Until recently, the average staple length of cotton was not long enough for this system to work effectively on cotton/polyester blends having a cotton content of more than 50 percent; the longer polyester fibers were required as the (external) wrapper fibers.

Recent substantial modifications have made the production of 100-percent-cotton yarns possible. Airjet spinning is gaining acceptance in the United States, particularly in the production of yarns for sheeting. Fiber fineness, length, and strength are most important to successful processing of cotton by this system.

Figure 13–10. View of a Rieter R1 open-end spinning machine (courtesy of Rieter Machine Works, Ltd.)

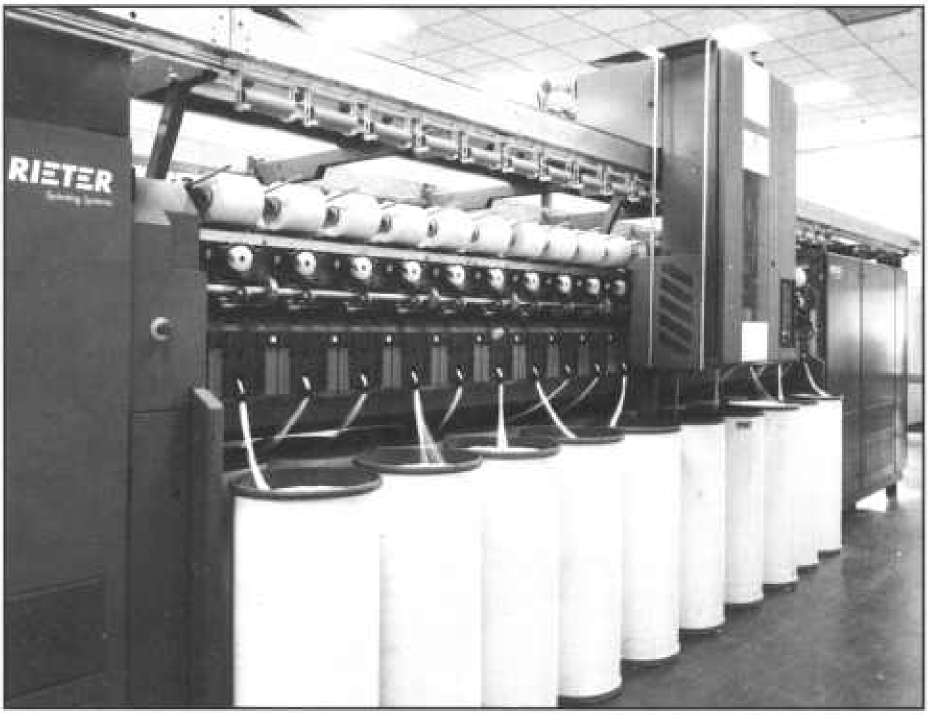
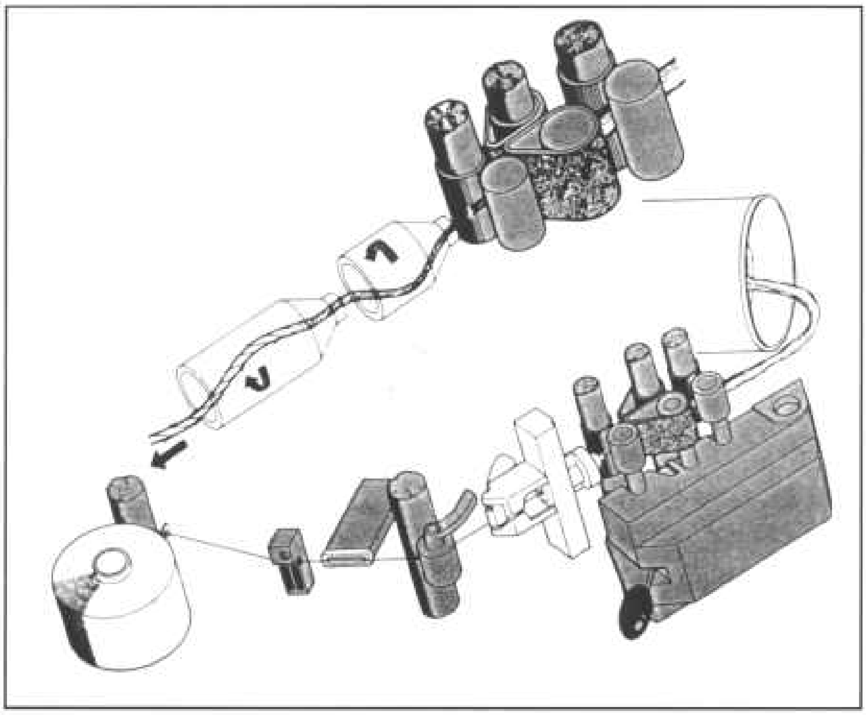


Figure 13–11. Schematic of an airjet spinning machine (courtesy of Murata Machinery, Ltd.)



Other spinning systems such as friction spinning (fig. 13–12) are on the market but have gained little acceptance in mills handling a high volume of cotton.

Warping and Slashing

To prepare yarns for the loom, the warp yarns—those laid in the direction of weaving of the fabric—are moved from the yarn packages to the so-called warp beam. To accomplish this the yarn packages are placed on a creel and individually run onto the beam of a machine called a warper. The warper runs at speeds of 1,000 ft/min or higher.

To protect cotton yarns in the warp from abrasion and breakage during weaving, they are coated with a protective material called warp size. The protective materials most commonly used on cotton yarns are starch or polyvinyl alcohol, but sometimes carboxymethyl cellulose is used. Sizes are applied on a machine called the slasher. On the slasher the warp yarns are drawn from the warp beam through a pad bath containing a water solution of the size. The warp yarns are then passed through an oven in which the water is evaporated off. The add-on level of warp size onto the yarns varies from about 5–9 percent. The warp yarns are collected on a loom beam, which is ready to be mounted behind the loom. From the beam the warp yarns are threaded onto the loom to get them ready for the weaving operation.

Weaving and Knitting

Presently, the two workhorse weaving technologies are known as flexible rapier and airjet filling insertion. Styling and fabric weight contribute to the decision regarding which of the two to use. The drive toward higher speeds in weaving and knitting continues at an increasing pace. The flexible-rapier weaving machines can insert filling yarn at nearly 1,900 yd/min on a 190-cm-wide machine; the airjet weaving machines operate at approximately 2,600 yd/min. Today's knitting machines are also ultra fast. For example, a 30-inch-diameter single jersey machine can operate at approximately 33 rpm, which equates to a knitting rate of approximately 85 yd of yarn/min. These fast machines require high-quality yarns. For efficient conversion into fabric, weaving and knitting yarns must be stronger, more even, and freer of yarn imperfections than ever before. To have these qualities, a yarn must be manufactured properly in the spinning plant and be made of high-quality fibers.

Dyeing and Finishing

Dyeing and finishing give the woven or knitted fabric its color and its aesthetic and functional characteristics. Finishing treatments include permanent press, waterproofing, sanding or mechanical finishing (for softer feel or "hand"), adding softeners, and others. These processes are carried out in plants separate from yarn, weaving, or knitting plants, generally in areas where water is plentiful.

Before dyeing and finishing occur, usually the woven greige (unbleached and undyed) fabrics are singed to remove surface hairiness. This process is particularly important when the cotton raw material has a high short-fiber content. Singers are gas burners that send jets of flame across the width of

Figure 13–12. Schematic diagram showing principle of friction spinning

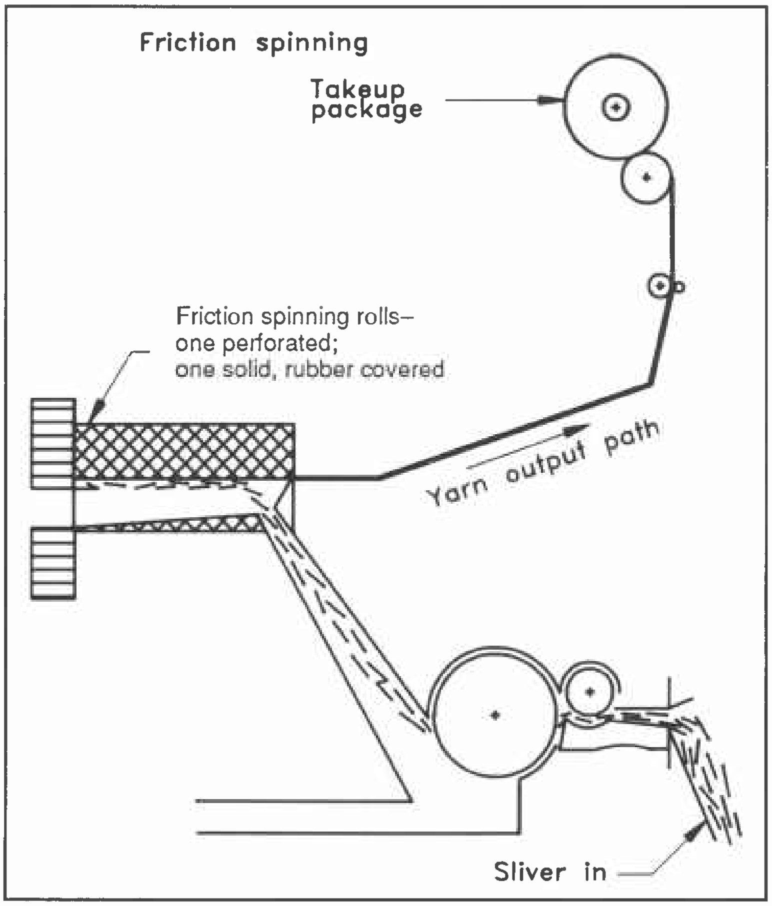
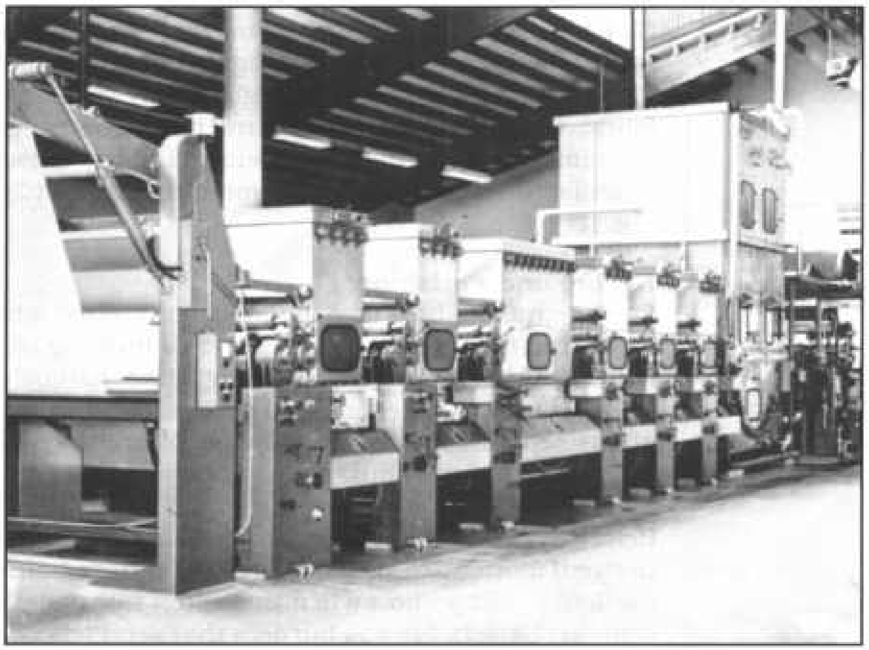


Figure 13–13. View of a typical (open-width) scouring and bleaching range. Process flow is from left to right.



the fabric face. The fabric is pulled at high speed (218–327 yd/min) through the full-width gas-flame front. Dust and protruding short fibers are burned off, leaving a much smoother fabric. Short fibers will continue to work their way to the surface, however, in subsequent stages of processing. Knitted fabrics are never singed; they have a loose, open structure and cannot be pulled under the tensions and at the speeds that woven fabrics withstand.

In the next process, the fabric is scoured with a combination of chemicals usually including soda ash or caustic soda. The warp size is dissolved or emulsified, and residual dust (from singeing) is washed off. Bleaching follows immediately thereafter to remove trash particles and any color in the fiber. Figure 13–13 shows a view of a typical, modern scouring and bleaching range.

Prior to dyeing, cotton fabrics may be mercerized, depending on end use and qualities desired. Mercerization is the treatment of cotton fabrics with cold, concentrated caustic soda (20 percent or higher). This process swells the fibers, allowing increased penetration of dyes in the subsequent dyeing process. Thus, it usually improves the dyeability of immature cotton specks and evens out the color. Since mercerization also requires additional steps to wash out and neutralize the caustic soda, it adds considerable cost. Many plants, particularly those dealing with knit goods, do not have mercerization ranges.

Dyeing can be a continuous or batchwise process that can involve a large variety of methods. The method chosen is dependent on the fiber composition. Unless the fabric has been mercerized, immature fibers or seedcoat fragments in substantial concentrations may show up as undyed spots or specks. As a result, the fabrics will be discounted 10–50 percent at the market, depending on the severity of the problem.

After dyeing, the fabric is further processed in finishing. This stage may consist of several processes. Permanent-press treatments require the fabric to be treated with a resin solution that (in a heat-curing step after drying) crosslinks the cotton. Crosslinking sets the fiber in the desired configuration before the resin is heat cured. The crosslinking process ensures that the fabric will remain smooth and resist wrinkling and takes place after the fabric is pressed. If permanent press is not desired, a so-called natural finish can be obtained by using fabric softeners. Sanforization—a form of compressive shrinking—may be applied to stabilize the fabric to minimize shrinkage in laundering.

Through all this processing, some fiber may continue to work to the surface, giving it a hairy appearance. As a final step, the fabric may be sheared to smooth the surface by using a machine having rotary knives.

Ginning

The effect of heat and overdrying on fiber properties is important to cotton gin and textile mill processing. For most cottons, the moisture content of lint cotton should be between 6 and 7 percent for optimum ginning and cleaning. Low lint moisture at ginning can cause a reduction in fiber length and a deterioration in the length uniformity. The adverse effect on length is due, in part, to heat degradation, which reduces the fiber's strength and makes the embrittled fiber more likely to break in subsequent ginning and cleaning. Shorter fiber lengths cause poorer spinning efficiency, reduced weaving and knitting performance, and possibly reduced yarn and fabric quality (primarily strength and appearance).

Too much moisture, on the other hand, can cause chokages during ginning and can reduce lint grades. Lower grades produced as a result of high moisture can cause difficulty in the textile mill. In the mill, cleaning and opening prior to carding becomes more difficult and the fiber is more likely to stick to processing rolls.

Summary

The customers for U.S. cottons—the textile industries throughout the world—continually modernize so that they can produce world-class quality yarns and fabrics at the highest possible efficiency and lowest cost. Modernizing equipment, however, is not the whole answer; the raw material (ginned lint) also plays a major role in accomplishing this objective. The yarnmaking system used determines which fiber properties are important. Generally, fibers are desirable if they are strong, fine, mature, long, uniform, and relatively free from neps, small trash, seedcoat fragments, and dust. Cotton breeders are spending much time and effort on improving the strength and fineness/maturity of most upland varieties. The use of proper harvesting and ginning techniques can preserve the properties of the lint and remove the objectionable nonlint to produce yarns of world-class quality.

APPENDIX A—DUTIES OF GIN PERSONNEL

William D. Mayfield, Bobby Greene, and Lon Mann

Cotton gins must be operated efficiently to be profitable. A dedicated, well-organized, well-trained crew can make the difference between a smooth-running, profitable cotton gin and a disaster.

Each gin must have a crew that is appropriate for the gin's capacity, degree of automation, management, and objectives. Some of the gin staff and crew positions, along with suggested qualifications and duties, are as follows:

MANAGER

Qualifications

- Business management knowledge and skills, including customer and employee relations
- Knowledge of gin machinery operation and maintenance, including the role of each machine in the system
- Knowledge of regulations relating to cotton ginning, including environmental regulations and employee and customer safety
- General knowledge of cotton production and textile manufacturing as related to ginning
- General knowledge of the quality potential of seed cotton and of the influence that gin processing has on final fiber quality

Duties

- Trains and supervises all gin personnel
- Makes decisions about machinery maintenance and repairs
- Recommends machinery modifications to owners when appropriate
- Assists superintendent as needed
- Maintains customer and public relations
- Collects accounts receivable
- Develops an individualized employee safety program for the gin and sees that the program is implemented

GIN SUPERINTENDENT

Qualifications

- Working knowledge of operation and maintenance of gin machinery, electrical equipment, burners, and safety devices
- Knowledge of seed cotton and lint moisture and their importance to ginning
- General knowledge of cotton and the expected influence of ginning on fiber quality

Duties

- Checks moisture content and trash level of seed cotton prior to ginning
- Supervises yard and gin crew activities
- Takes responsibility for routine maintenance and minor repairs

- Directly supervises the crew
- Makes sure the gin operates smoothly
- Assists gin stand operator occasionally
- Supervises cleanup and housekeeping operations
- Acts as fire chief when a fire occurs
- Assigns people to make repairs
- Acts as assistant manager when on duty
- Conducts employee safety training programs for the crew

GIN STAND OPERATOR

Qualifications

- Knowledge of proper gin operation and maintenance

Duties during operation

- Devotes full time to gin stands
- Watches for and immediately removes tags from ribs
- Adjusts feed control and keeps stands operating at capacity
- Constantly checks for possible maintenance problems
- Watches for fires
- Acts as assistant gin superintendent
- Watches for hazardous conditions and unsafe practices and corrects them or points them out to the supervisor

Duties during lubrication and cleanup

- Checks gin stand, mote conveyors, saws, and ribs for problems
- Checks drive belts, pulleys, and motors
- Checks feeder saws, brushes, and screens
- Informs the supervisor when problems occur
- Replaces guards or safety devices that may have been removed or disconnected
- Helps inspect and clean overhead machinery

Duties during a gin stand fire

- Cuts off feed control
- Closes front of stands to spill cotton out of the stands and onto the floor
- Cuts off feeders
- Disengages gin stands
- Sees that machines are kept running unless overhead equipment is choked

LINT CLEANER OPERATOR

Qualifications

- Working knowledge of lint cleaners and their components

Duties during operation

- Keeps grid bars clean
- Checks trash conveying system for tags or maintenance requirements
- Checks for irregularities in the flow of cotton
- Assists gin stand operator as needed
- Keeps machines and floor clean
- Keeps all guards and safety devices in place and operational

Duties during lubrication and cleanup

- Locks out power to lint cleaner drive motor before doing any maintenance
- Opens all doors and inspects for problems such as tags or damaged saw teeth
- Checks condensers for screen damage or tags
- Checks brushes for uniformity and damage
- Checks lint flues for tags
- Cleans machines and floor around them
- Reports problems to supervisor

Duties during a fire

- Assists gin stand operator
- Checks lint cleaners for smoldering trash and removes cotton tags or wraps around shafts before restarting the lint cleaners

PRESS CREW

Duties of the press operator during operation

- Operates the press or supervises those operating the press
- Assists others in tying out bales and dressing the press
- Constantly checks on lint slide and tramper
- When not tying out a bale, stands or sits where machinery can be observed
- Keeps safety devices in place and corrects any unsafe practices around the press

Duties of press assistants during operation

- Keep press supplies available
- Tag and transport cotton to platform
- Draw samples if required
- Perform general housekeeping.

APPENDIX B—PORTABLE MOISTURE METERS

W.S. Anthony

Moisture content is a major factor affecting the cotton ginning process from unloading through bale packaging. Moisture management is critical to cotton cleaning in gins and textile mills and makes an impact on the consumer in the form of fabric quality.

Portable moisture meters commonly used in cotton gins primarily measure lint moisture, not seed cotton moisture. Consequently, the lint scale on these meters should be used instead of the seed cotton scale for reading moisture of lint and seed cotton unless the manufacturer specifically states otherwise. Lint moisture reaches equilibrium with the humidity in the air within a few minutes; however, seed cotton moisture takes hours or days to equilibrate due to the influence of the seed.

All moisture meters must be calibrated before use. Calibration is performed by comparing actual moisture content (measured by comparing sample weight to dry weight) with the meter's measured moisture content. Such a comparison gives a calibration curve. However, thorough calibration is not practical on a routine basis and the manufacturer's reference check is normally used. Typical calibration curves for one model of a hand-held moisture meter are shown in figures B–1 and B–2. Figure B–1 illustrates actual lint moisture levels between 6 and 12 percent as a function of meter readings on the lint scale. Figure B–2 illustrates seed cotton moisture levels from 6–18 percent as a function of meter readings on the lint scale. The samples in figure B–2 were allowed to equilibrate before testing. The equilibration was similar to that which would occur after several days of storage in a module or trailer at relatively constant temperature and humidity.

Some meters do not measure lint moisture below 4 percent or above 8 percent. Generally, if the lint moisture reading is below 5 percent, no drying is required. A standard deviation (a measurement of the error) of ± 1.0 percent moisture content is normal for these types of meters. In addition, it is not unusual for the calibration curve to be slightly skewed so that the meter indication of moisture is not exact. Meter readings are influenced by cotton type, area grown, contaminants such as trash, sample and ambient temperature, and sample density.

Meter Use

Moisture meters are invaluable to cotton ginners. They are useful on the farm to determine when to harvest and when to module. On the gin yard, meters can be used for grouping trailers or modules having similar moisture contents to facilitate smooth ginning and to identify the cotton that must be ginned immediately.

When moisture readings of seed cotton are taken, five or more readings should be taken at different locations. These readings should be averaged because wide differences in moisture within the same field, trailer, or module are common. Meter readings should be taken on the correct scale as identified by the meter manufacturer. Readings should be taken at least 1 ft below the surface or 1 ft from the side of trailers or modules because the cotton

Figure B–1. Actual lint moisture as a function of lint moisture measured by a portable moisture meter

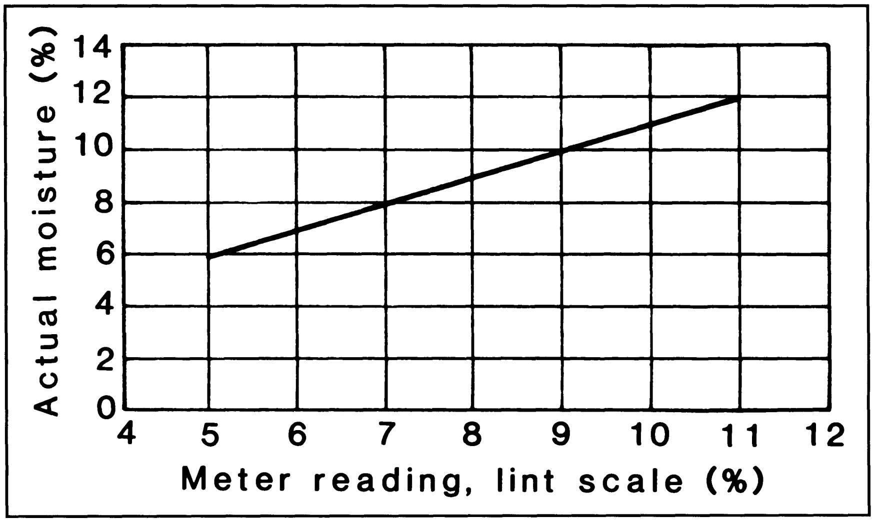
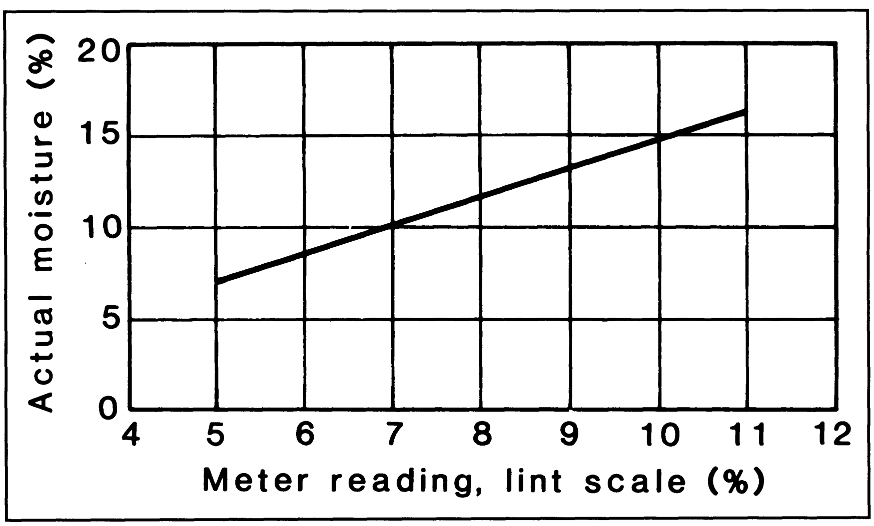


Figure B–2. Actual moisture content of equilibrated seed cotton as a function of seed cotton moisture measured by a portable moisture meter



moisture level near the surface changes rapidly with changes in the ambient air relative humidity. Data should be recorded on the trailer or module and at the gin.

The size of the sample for testing should be no smaller than that recommended by the instrument manufacturer. It is usually better to use a little too much cotton in the cup than too little. Care should be taken to avoid transferring moisture from hands to the cotton when the sample is taken. Hand pressure and quantity of cotton should be consistent to ensure reliable readings. Meters are usually factory calibrated; manufacturers usually include methods of verifying the calibrations of their meters, either automatically or manually by an adjustment on the meter. These methods also check the battery voltage and should be routinely used each day before measurements are made.

Within the gin, seed cotton moisture measurements at the feed control and at feeder aprons and lint moisture measurements after the first lint cleaner condenser and at the lint slide can be most helpful. The seed cotton moisture at the feed control is indicative of how much drying is initially required, and the moisture at the extractor-feeder apron indicates how much drying has been done as well as whether more drying is needed.

When any type of moisture meter is used, readings can be improved by the following procedures:

1. Use uniform, homogeneous samples of about the same weight.
2. Wear latex gloves.
3. Place each sample in the measuring cup immediately to minimize moisture change in each sample.
4. Compress each sample uniformly with the same amount of pressure each time.
5. Verify calibration periodically against the oven drying (gravimetric) method.
6. Follow manufacturer's recommendations.
7. Verify the status of the internal circuitry of the meter before each use.

Types of Portable Moisture Meters

Electrical moisture meters suitable for use at gins are of two types: electrical-resistance type (sometimes called the conductance type) and the capacitance type (also called the dielectric type). The electrical-resistance type operates on the principle that the resistance of a mass of cotton to the flow of an electric current increases as the cotton becomes drier. The capacitance type operates on the principle that the capacitance of an electrical condenser varies with the moisture content of a mass of cotton placed between the condenser plates.

The electrical-resistance-type meter has been widely accepted in the ginning industry, and a number of makes and models are commercially available. Figure B–3 depicts two resistance-type models commonly used to estimate moisture in cotton. The resistance type responds more rapidly to variations in moisture conditions than does the capacitance type. Manufacturers of resistance-type meters suitable for gin use offer multiple-use probes, sample chambers (cups), and a number of accessory sample electrodes that make the instrument useful for moisture measurement of seed cotton, cottonseed, and lint.

Figure B–3. A Granberry moisture meter (left) and a Delmhorst model CM–1 (right)

Some manufacturers offer bale probes that consist of two parallel probes that are about 8 inches long and that are insulated except near the point to eliminate the effects of moisture in the outer few inches of a bale. If the insulation is worn or chipped, the probes should be replaced. Modified flat-density (12–14 lb/ft^3) bales and universal density (28 lb/ft^3) bales will appear to have different moisture contents due to the differences in densities. Voids or low-density areas in a bale should not be used for moisture measurements. If obvious changes occur in the force required to insert the probe, the reading should be discarded.

Maintenance

Moisture meters should be given reasonable care. Although they are generally ruggedly constructed, the internal components and the movement of the needle can be damaged by severe mechanical shocks. Meters with Bakelite cases should be protected from cracking or breaking.

Most difficulties encountered with portable instruments are due to battery troubles. Corrosion is serious and may result from battery leakage. Failure to remove batteries when the meter will not be used for prolonged periods usually results in battery wall failure, which permits battery liquids to escape and attack the internal components of the meter. At the close of the ginning season, batteries should be removed and discarded because they usually will not be suitable for further use. When installing batteries, be sure the correct wires are attached to the positive and negative battery terminals so that polarity is observed.

Cautions

The temperature of the sample affects the moisture reading of a resistance-type meter. For accurate moisture readings, temperature corrections should be made according to the manufacturer's recommendations. This is generally not serious if the sample temperatures are within the range of 60–80 °F. Temperatures at the feeder apron, however, often exceed 80 °F. Lint moisture readings after the first condenser are recommended in lieu of seed cotton readings at the extractor-feeder apron.

Inaccurate readings from resistance-type meters can also be caused by excess surface moisture in cotton (which may occur in cotton harvested after a dew or rain or in cotton that has been passed through a moisture-restoration device) and static electricity. Static electricity can cause reading errors and erratic deviations in the meter needle. This problem generally occurs only in dry weather, particularly when it's cold. Static charges on the meter can be removed by wiping the meter with a damp cloth. Sometimes electrical grounding of an instrument will improve its operation when static charges are present.

APPENDIX C—PINK BOLLWORM CONTROL IN GINS

S.E. Hughs and
Marvis N. Gillum

The western portion and some midsouth areas of the U.S. Cotton Belt are infested with pink bollworm, *Pectinophora gossypiella* (Saunders) (USDA, Animal and Plant Health Inspection Service, Plant Protection and Quarantine Programs 1979). This insect can cause severe damage to cotton, okra, and kenaf. Under the provisions of sections 8 and 9 of the Plant Quarantine Act of August 20, 1912, and section 106 of the Federal Plant Pest Act (7 U.S.C. 161, 150 ee), the Secretary of Agriculture quarantined certain States and requires that specific regulations be followed to prevent the buildup and spread of the pink bollworm (USDA, Animal and Plant Health Inspection Service, Plant Protection and Quarantine Programs 1979). These regulations pertain to the treatment and movement of seed cotton, cotton lint, cottonseed, and related products within and from regulated areas. Cotton producers, ginners, and seed processors are affected by these regulations.

Pink Bollworm Regulations

Plant protection and quarantine regulations are enforced by each of the States and the Animal and Plant Health Inspection Service (APHIS), which is an agency of the U.S. Department of Agriculture. Assistance with specific problems or information on current regulations may be obtained by calling local APHIS representatives listed in the phone book under U.S. Government, Department of Agriculture.

The Code of Federal Regulations (7 CFR 301.52–10), as revised February 18, 1988, designated certain States or parts of certain States as pink bollworm regulated areas. The regulated areas are in nine different States and are classified as either generally infested or suppressive. This information is summarized in the following:

State	Generally infested area	Suppressive area
Arizona	Entire State	None
Arkansas	None	All or parts of the following counties: Chicot, Desha, Drew, Jefferson, Lincoln, Monroe, and Phillips
California	All of the following counties: Imperial, Inyo, Los Angeles, Orange, Riverside, San Bernardino, and San Diego	All of the following counties: Fresno, Kern, Kings, Madera, Merced, San Benito, and Tulare
Louisiana	None	Caddo Parish

State	Generally infested area	Suppressive area
Mississippi	None	Parts of the following counties: Bolivar and Washington
Nevada	All of the following counties: Clark and Nyle	None
New Mexico	Entire State	None
Oklahoma	Entire State	None
Texas	Entire State	None

The following articles may not be moved from any regulated area of a State to another State except with an appropriate certificate or permit obtained from the State Plant Protection Agency (USDA, APHIS, Plant Protection and Quarantine Programs 1988):

1. Upland cotton and wild cotton, including all parts of these plants
2. Seed cotton
3. Cottonseed
4. Cotton lint, linters, and lint cleaner waste from American pima varieties except for material compressed to a density of at least 22 lb/ft^3 and except for trade samples of American pima cotton lint and linters (The articles hereby exempted remain subject to applicable restrictions under any other State quarantines that might exist and must not have been exposed to pink bollworm infestation after ginning or compression as prescribed.)
5. Cotton waste produced at cotton gins and cottonseed oil mills
6. Cotton gin trash
7. Used bagging and other used wrappers for cotton
8. Used cotton harvesting equipment, used cotton ginning equipment, and used cotton oil-mill equipment
9. Any other product, article, or means of conveyance not covered in items 1–8 that an inspector believes to be a risk for spreading pink bollworm.

A permit must be attached to articles from a quarantined area or State if the articles are being moved (1) from any regulated area into or through any point outside of the regulated area, (2) from any generally infested area into or through any suppressive area, (3) between any noncontiguous suppressive areas, or (4) between contiguous suppressive areas when the inspector believes that the regulated articles may spread pink bollworm.

A permit is not necessary if the articles from a regulated area are being moved (1) from a generally infested area to a contiguous generally infested area, (2) from a suppressive area to a contiguous generally infested area, or (3) between contiguous suppressive areas unless the person in possession of the articles has been notified by an inspector that the move may spread pink bollworm.

If an article in a regulated area originated outside of the area, that article can be reshipped from the regulated area without a permit as long as (1) its point of origin is clearly indicated, (2) its identity has been maintained, (3) it has been safeguarded against infestation while in the regulated area in a manner satisfactory to the inspector, and (4) it will not be shipped through a regulated area.

Cottonseed

In general, cottonseed can move freely to oil mills within the generally infested or suppressive regulated areas without treatment.

Cottonseed may be eligible for movement outside the regulated area if it is (1) heated to 150 °F for at least 30 sec or 145 °F for at least 45 sec or (2) fumigated with methyl bromide, hydrocyanic acid, or aluminum phosphide. Most acid and flame delinting plants that process cottonseed for planting prepare seed for movement by heating it. Cottonseed may also be eligible for movement if it is processed by the oil mill on arrival. During host-free periods, seed may be moved from a generally infested area to a suppressive area or from a suppressive area to an unregulated area when permitted by APHIS.

Gin Trash

Quarantine regulations affect the disposal of gin trash. Several approved methods may be used to treat gin trash prior to disposal, but the single-fan treatment method is used most. If gin trash is passed through the wheel of a conventional trash fan (fig. C–1) operating according to pink bollworm quarantine regulations, the action of the fan will kill the pink bollworms in the trash. Fan parameters and proper operating conditions include the following (Robertson et al. 1959, 1963; Hughs and Staten 1994):

1. No fan should be used if its wheel diameter is less than 19 inches.

2. The housing or scroll should be constructed of plate steel or cast iron and may be lined with hard rubber.

3. Fan housing should be patched by inserting and welding plate or cast-iron insertions. No patching should be done with belting, sacks, rubber, or any other shock-absorbing substance, but the fan housing or scroll and piping elbows may be lined with rubber if desired.

4. No gin trash wheel should be used in an oversized casing; oversized or standard wheels may be used in standard casings only.

5. The wheel must be laterally centered to have equal clearance in the front and back.

6. The fan wheel may be either a standard straight, forward, reverse, or curved tip having not fewer than six blades.

7. Trash must enter at a 90° angle to the fan wheel. This may be accomplished by using either a straight inlet pipe or a 90° elbow (fig. C–1); however, banjo-type elbows and adapters approved by APHIS are acceptable.

8. Fan wheel speeds should comply with the speeds shown in table C–1. Fans of larger diameter than 32-1/2 inches should have a minimum tip speed of 13,000 ft/min.

Figure C–1. Approved pink bollworm fan and inlet connections

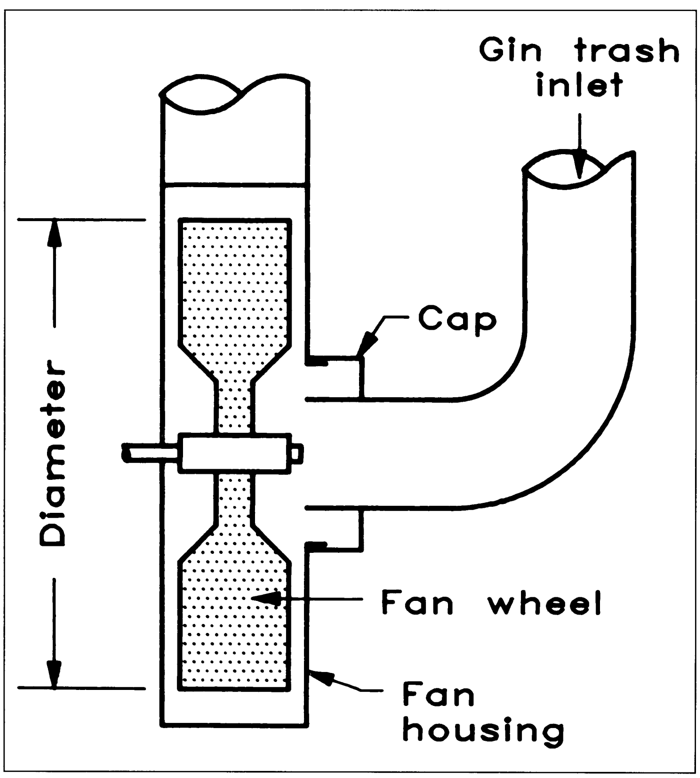


Table C–1.
Federal pink bollworm quarantine requirements regarding wheel diameter, inlet size, and speed of single fans for treating gin trash

Fan wheel diameter (inches)	Maximum inlet size (inches)	Minimum tip speed (ft/min)
19	10 to 10-1/2	13,730
19-1/2	10 to 10-1/2	13,730
20	10 to 10-1/2	13,720
20-1/2	10-1/2 to 11	13,740
21	10-1/2 to 11	13,690
21-1/2	10-1/2 to 11	13,675
22	10-1/2 to 11	13.705
22-1/2	10-1/2 to 11	13,725
23	10-1/2 to 11	13,730
23-1/2	11-1/2 to 12	13,720
24	11-1/2 to 12	13,695
24-1/2	11-1/2 to 12	13,725
25	11-1/2 to 12	13,680
25-1/2	11-1/2 to 12	14,020
26	11-1/2 to 12	14,020
26-1/2	11-1/2 to 12	14,015
27	12 to 12-1/2	13,995
27-1/2	12 to 12-1/2	13,965
28	12 to 12-1/2	14,000
28-1/2	12 to 12-1/2	14,025
29	12 to 12-1/2	13,970
29-1/2	12 to 12-1/2	13,980
30	12 to 12-1/2	14,060
30-1/2	12 to 12-1/2	13,975
31	12 to 12-1/2	14,000
31-1/2	12 to 12-1/2	14,020
32	12 to 12-1/2	14,240
32-1/2	12 to 12-1/2	14,465
42-1/4	([1])	13,000

[1] See notes 9 and 10 in section on gin trash in this appendix.

9. In the event that the inlet pipe is smaller in diameter than the fan housing inlet, the pipe size should remain the same up to and through the fan housing and the pipe should protrude inside (at least five-eighths inch past the fan housing) as shown in figure C–1. Tapered-cone inlet adapters should not be used to connect the inlet pipe to the fan housing inlet unless the pipe is larger in diameter than the inlet.

10. The diameter of the inlet pipe to the fan should not exceed the diameter of the pipe delivering material to the inlet pipe.

Lint Cleaner Waste and Motes

Lint cleaner waste and motes are not considered gin trash. However, quarantine requirements for handling these materials are essentially the same as for those handling gin trash. The single-fan method of treatment specified for handling gin trash is appropriate for handling lint cleaner waste and motes with the following exceptions:

1. Minimum fan wheel diameter may be 18 inches. (Minimum speed for an 18-inch-diameter fan used for lint cleaner waste or motes is 2,550 rpm.)

2. Minimum fan speeds may be reduced 12 percent from those shown in table C-1.

SAFETY WARNING: Fans must not be operated above their designed maximum safe speed. Fan manufacturing companies can supply information on safe operating speeds. As a general rule, tip speed of gin trash fans should not exceed 15,000 ft/min for safe operation.

Gin Machinery and Equipment

Mechanical cotton processing machinery that has been used in regulated areas must be fumigated with methyl bromide according to APHIS regulations before it may be transported to unregulated areas. However, storage of unused gin equipment for 2 yr prior to shipment is also considered adequate treatment.

Evaluating Gin Systems for Pink Bollworm Kill Potential

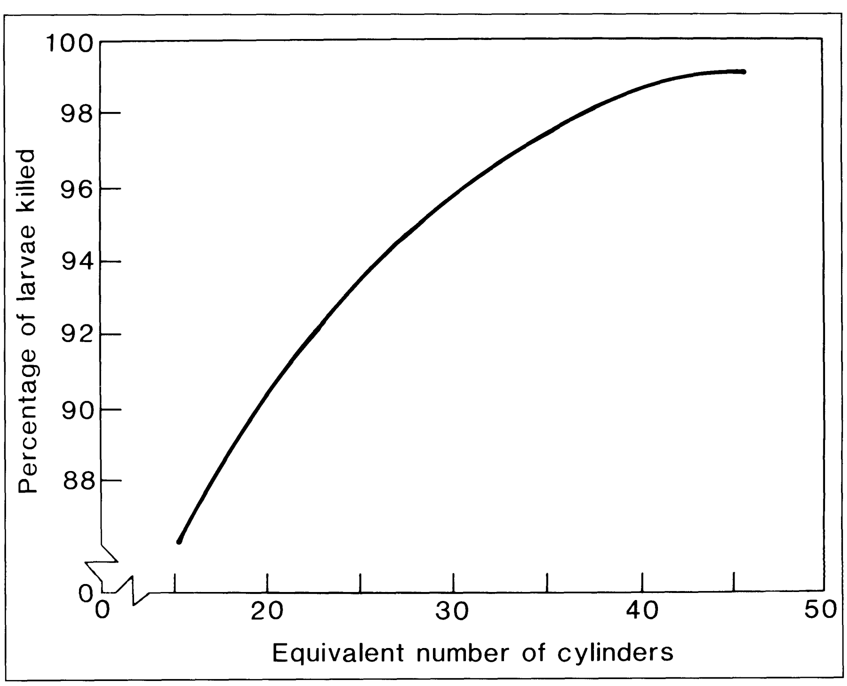
A high percentage of pink bollworms are killed during the cotton ginning process. Research has shown increasing kill percentage with increasing complexity of the gin setup. This research has also shown that the capability of a system for killing pink bollworms during processing is related to the number of cleaning cylinders in the overhead cleaning system and to the equivalent cleaning cylinders in various other pieces of equipment in the system. Table C–2 shows the number of equivalent cleaning cylinders for various pieces of equipment and shows a tabulation form for rating the gin system (Graham et al. 1967). The expected percentage of pink bollworm kill based on the equivalent total cylinders in the gin system is found in figure C–2.

Table C–2.
Sample form for rating gins for pink bollworm kill

Equipment item	Equivalent cylinders (each)	Number of items	Total cylinders
Dryer[1]	2	______	______
Cleaner	Actual	______	______
Bur extractor or stick machine	3	______	______
Separator	4	______	______
Extractor feeder	6	______	______
Gin[2]	10	______	______
Seed blow system	3	______	______
		Total	______
		Percent kill	______

[1]Based on 24-shelf dryer having no heat.
[2]If gin is operating below 600 rpm, it should not be rated because its kill rate will be so low.

Figure C–2. Percentage of pink bollworms killed as a function of equivalent number of cleaning cylinders in ginning equipment



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GLOSSARY

Absolute humidity: The weight of water vapor existing in the atmosphere. It is usually expressed either as grains per cubic foot or pounds per pound of dry air.

Airblast gin: A gin that doffs the ginned lint from the saws by a blast of air.

Air line cleaner: A machine in which the cotton is cleaned and conveyed while in the gin suction piping—that is, in the air line.

Automatic feed control: Apparatus for automatically controlling the volume of seed cotton flow to the ginning system.

Bale density: A unit of measurement of weight per unit volume. Normally expressed as pounds per cubic foot. Density is calculated by dividing the net bale weight by the bale volume in cubic feet. Volume is determined by multiplying bale length, width, and thickness dimensions expressed in feet. Thickness is determined by measuring from tie to tie across the crown of the bale.

Boll separating device: A device on the stripper-type harvester to separate the immature and unopened bolls from the open, mature bolls.

Bollie: A cotton boll that is dry but not open because of weather, insect, or disease damage.

Boot: The flexible canvas at the upper end or bell of the telescope. May also be made of metal.

Breast: Front of a gin stand.

British thermal unit (Btu): The quantity of heat required to raise the temperature of 1 lb of water 1 °F.

Brush gin: One that doffs the ginned lint from the saws by a brush.

Bypass: A passage around a machine to avoid use of that machine.

Cleaner: A machine for removing dirt and small trash from seed cotton. Does not do extracting.

Cleaning feeder: A cleaner and feeder combined.

Compress universal density bale: A flat/modified flat cotton bale recompressed at the warehouse to a density of at least 28 lb/ft^3.

Concurrent flow dryer: See parallel flow dryer.

Condenser: A machine to collect ginned lint into a smooth, endless batt.

Conveyor distributor: An overhead auger that delivers seed cotton to the individual extractor feeders and gin stands.

Cotton ties: Strips of thin steel or wire bands wrapped around cotton bales to secure the bale. The ties are secured on the bale before it is released from the press.

Counterflow dryer: A dryer in which hot air enters one end and the material to be dried enters the opposite end. The reverse of a parallel flow or concurrent dryer.

Cyclone or collector: A device for separating solid materials from a conveying airstream.

Cylinder cleaners: Gin cleaners that use spiked cylinders to scrub seed cotton over grid rods to remove foreign material.

Defoliation: Natural or artificially induced shedding of leaves from the cotton plant. Chemicals are normally used to defoliate cotton plants to aid mechanical harvesting.

Desiccation: Killing of leaves on the cotton plant with a chemical. Leaves do not wilt and fall off the plant as in defoliation.

"**Dinky" press:** Small bale used at cotton compress establishments for squeezing the bale together to permit removal of ties.

Distributor: A device that distributes seed cotton to various machines or cotton gins. Excess cotton from this device is discharged at the overflow. A distributor may be of the belt type, pneumatic, or equipped with an auger or helical screw.

Doffer rolls: Rolls that doff or strip the ginned lint from the condenser drum.

Doffing: The act or process of removing cotton lint from any part of a machine.

Dryer: Apparatus for lowering the moisture content of seed cotton.

Extractor: A device for extracting burs, stems, whole leaves, and other trash from seed cotton. Although it does some cleaning, it should not be confused with a cleaner.

Extractor unit: A small extractor suitable for replacing a cleaning feeder over a gin stand (usually made in gin stand widths).

Feeder: See cleaning feeder.

Feeder apron: The apronlike discharge pan from feeder into gin stand.

Fixed seal: Strapping connection in which relative movement of strap ends cannot occur. Refers to either triple notch or keylock seal.

Flat/modified flat bale: A cotton bale with a density of less than 23 lb/ft^3. Flat bale density is normally 12 lb/ft^3, and modified flat bale density is normally 14 lb/ft^3. Unless otherwise noted, reference to flat bales in specifications also includes modified flat bales.

Float board: The flap at the back of the roll box in an automatic roll-density control on a cotton gin.

Gin model: An economic simulation model that calculates the per bale cost of ginning cotton at various annual volumes and conditions.

Gin stand: Machine for separating lint from seed.

Gin standard density bale: A cotton bale compressed at the gin to a density of at least 23 lb/ft^3 but less than 28 lb/ft^3.

Gin universal density bale: A cotton bale compressed at the gin to a density of at least 28 lb/ft^3.

Gin yard trailer: A module mover mounted on a trailer that is usually powered by a farm tractor.

Green boll: A cotton boll that is neither dry nor open.

Heat: A form of energy that causes a body or substance to rise in temperature. Heat energy is transferred by virtue of a temperature difference and is measured in British thermal units (Btu).

Heater: Unit for supplying heat to a cotton dryer.

Huller breast: The front of a huller to which the huller ribs are attached.

Huller ribs: The front set of ribs in a double-rib gin.

Keylock-type seal: One type of fixed-seal strapping connection in which one strap end contains metal tabs for insertion into another strap end containing slots. Approved for use on 0.75-inch by 0.025-inch strap in an 8-band configuration or 0.75-inch by 0.031-inch strap in a 6-band configuration.

Lambrequin: The lever of the seed board; also the seed fingers in a gin stand.

Lay-by herbicide: A chemical weed killer applied at lay-by time to kill weeds as they emerge.

Lint cleaner: Machine for removing foreign matter from lint cotton.

Lint flue: Flue or pipe to carry off ginned lint.

Lint moisture content: The percentage of moisture in the fiber based on the wet weight.

Lint moisture percent: $\dfrac{\text{Wet weight} - \text{dry weight} \times 100}{\text{wet weight}}$

Lint regain: The percentage of moisture in lint based on its dry weight.

Lint regain percent: $\dfrac{\text{Wet weight} - \text{dry weight} \times 100}{\text{dry weight}}$

Magnet: A magnetic devise used in various locations in the ginning system to remove metal objects from cotton.

Module: A stack of seed cotton normally containing 12–14 bales of picked cotton or 8–10 bales of stripped cotton.

Module builder: A machine that compacts seed cotton into modules in the field for storage prior to ginning.

Module pallet: A metal sheet on which a seed cotton module is formed. Although used extensively in the 1970's, pallets are now used only in fringe cotton production areas.

Module truck: A truck equipped with a chain bed that loads, transports, and unloads seed cotton modules.

Moisture content: Can be determined on a wet basis or on a dry basis. On a wet basis, moisture content is determined by

$$\frac{\text{Weight of moisture in sample} \times 100}{\text{Weight of sample}}$$

On a dry basis (using the gravimetric or oven-drying method), moisture content is given by

$$\frac{\text{Original weight} - \text{dry weight} \times 100}{\text{(Dry weight)}}$$

In both methods, moisture content is expressed as a percentage. The latter method does not have a universal designation and is variously called "moisture content, dry basis," "regain," or "moisture ratio." However, the use of the dry-basis method is preferred in drying studies because it simplifies computations. When the wet-basis method is used, both the moisture content and the base on which it is computed change during drying; but in the dry-basis method the base remains constant. Moisture content on a wet basis may be converted to that on a dry basis by the following formula:

$$\frac{100 \times \text{(moisture content, wet basis, in percent)}}{100 - \text{(moisture content, wet basis, in percent)}}$$

Mote: Immature seed with short, immature fiber attached.

Mote board: A partition in the gin stand, usually movable, to deflect motes.

Moting: The casting out of motes. May be done by gravity or by centrifugal force.

Multipath dryer: A dryer with several paths to provide various exposure times so that cotton of various moisture contents can be dried properly.

Naps: Large entanglements of cotton fiber.

Neps: Small, pinhead-size entanglements of fibers in cotton that show up in ginned lint, card web, yarns, and cloth. Neps are objectionable in the textile industry because they may cause yarn breakages and improper dyeing.

Overflow: Excess cotton that is fed into the ginning system and that accumulates at a designated point.

Overhead cleaners: A general term usually including all the machinery in the seed cotton cleaning system.

Packer: See tramper.

Panel: Rectangular sheet of fabric; refers to top sheet in bag and panel combination; or to one-half pattern of new jute, sugar bag, cotton, or woven polypropylene covers used on gin universal or gin standard density bales.

Parallel flow dryer: The type of dryer in which both the hot air and the material to be dried enter the same end of the dryer and move in the same direction. Also called concurrent flow dryer.

Pattern of bagging: The two pieces of material pressed together when covering cotton bales.

Picker roll: A special beating or extracting roller in the front, or breast, of a cotton gin.

Picker-type harvester (or spindle picker): A harvesting machine that removes cotton from the burs with rotating spindles, leaving unopened bolls on the plant; also described as a selective harvester.

Picking head (or drum): Part of a spindle picker where the cotton is removed from the plant and placed in a conveying system.

Plant lifters: Guides or fingers that lift lower branches and guide the cotton plant into the harvester.

Postemergence herbicide: A weed-killing chemical applied soon after cotton emerges. Spray is directed on small weeds below the cotton leaves.

Preemergence herbicide: A residual weed-killing chemical applied to the soil for several weeks before the cotton emerges. Kills weeds as they emerge.

Pressure plates: The hinged, spring-loaded metal wall opposite the picker spindles that presses the plant toward the spindles.

Rain-grown cotton: Cotton grown in areas where rainfall is sufficient and irrigation is not needed.

Ram: The hydraulic lifting and compressing element of a press.

Relative humidity: A measure of the dryness or dampness of air; is defined as the part or fraction of invisible water, in the form of vapor, actually present in air as compared with the maximum moisture the air can hold at a given temperature and atmospheric pressure. It is expressed as a percentage. It is also defined as the ratio of the pressure exerted by the water vapor in the air (called the partial pressure of water vapor) to the pressure of saturated water vapor at the same temperature. When air is saturated with water vapor, its relative humidity is said to be 100 percent; if it contains three-fourths as much water vapor, its relative humidity is 75 percent. A relative humidity of zero signifies that the air contains no water vapor.

Rembert fan: A fan that allows seed cotton to pass through without damaging the seed or fiber.

Rock and boll trap: A device for separating heavier materials from seed cotton.

Roll box: A compartment holding the seed cotton in contact with the gin saws. Also called a seed-roll box.

Rolling bales: Cotton bales that are unevenly packaged from a weight distribution standpoint at the gin and that roll out of shape during the repressing operation at the compress unless supported by side doors.

Seed belt: A moving belt in the gin that conveys seed away from the gin stands.

Seed board: An adjustable, fingered plate at the bottom of the roll box.

Seed cotton: Harvested cotton before the lint is removed from the seed.

Seed cotton mass: Harvested material in the trailer. Includes seed cotton, plant material, and other foreign matter.

Seed cotton moisture content: The quantity of moisture in seed cotton. Usually expressed as a percentage. Includes moisture in fiber and in seed.

Seed dryer: Apparatus for lowering the moisture content of cottonseed.

Seed-o-meter: Trade name of a device for automatically measuring cottonseed.

Seed roll: A roll of seed cotton in the roll box.

Seed-roll box: See roll box.

Selective harvester: See picker-type harvester.

Separator: A machine that separates seed cotton from the air currents of the suction fan.

Serpentine cleaner: A seed cotton cleaner that has no moving parts and that removes trash from airborne cotton.

Slip seal: A type of strapping connection used to secure strap ends together. Seal has heavy indentions across width of strap. Connection allows for limited movement or slippage of bottom strap. For use with 0.75-inch by 0.025-inch strap in either a 6-band or 8-band configuration.

Specific heat: The heat measured in British thermal units (Btu) required to raise 1 lb of material 1 °F. The specific heat of air is 0.24 Btu/lb/°F; that is, 0.24 Btu applied to 1 lb of dry air will raise its temperature 1 °F. The specific heat of cotton has been given as approximately 0.3 Btu/lb/°F.

Specific weight: The weight of an object in relation to its volume. Commonly expressed as lb/ft^3.

Spindle bars: Picker spindles mounted in a vertical tubular housing called a bar.

Spindle moistening pads: Rubber pads through which water is applied to moisten picker spindles as they pass by.

Spindle picker: See picker-type harvester.

Spindle twists: Small tufts of cotton twisted tightly into a wad.

Spiral-sewn bag: A bag made of burlap, cotton, or polypropylene. The fabric of the bag is sewn on a bias, resulting in a tube with the seam spiraling around the bale circumference.

Standard density bale: A cotton bale compressed to a density of at least 23 lb/ft^3 but less than 28 lb/ft^3.

Stick machine: A device for removing sticks and green leaves from seed cotton.

Strapping: High-tensile steel material having a flattened rectangular cross section. Applied to restrain cotton bales after compression.

Stripper-type harvester: A harvesting machine that pulls or strips all cotton bolls—open and unopen—from the plant.

Stripping rolls: Two tubular rolls, or one roll and a stationary bar, in a stripper-type harvester that remove bolls by passing the plant through a narrow slot between them.

Telescope: Telescopic suction pipe for unloading seed cotton.

Tramper: Part of the press mechanism. Also called a packer.

Triple-notch strapping connection: A type of fixed-seal strapping connection in which strap ends are secured by indenting and locking a metal seal around strap ends. For use with 0.75-inch by 0.031-inch strapping in an 8-band configuration only.

Turnrow: The unplanted space that allows machinery to be turned at each end of a field.

Two-sided bale: A cotton bale that contains lint of one grade or staple length on one side and lint of a different grade or staple length on the other side.

Universal density bale: A cotton bale compressed to a density of at least 28 lb/ft^3.

Vacuum wheel or feeder: An apparatus that seals an opening against air leakage while allowing materials to pass.

Vapor pressure: The pressure exerted by pure vapor in equilibrium with the substance named. For example, the vapor pressure of water at 212 °F is 29.92 inches of mercury at sea level (or one atmosphere) and is the pressure of water vapor in equilibrium with liquid water at 212 °F.

Wetting agent: A surfactant or detergent added to the water to help moisten spindles and improve spindle cleaning.

Wires: Slender metal rods used to restrain cotton bales after compression. In cross section, they are round or oval.

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